

5.0 TRACE METAL CONCENTRATIONS

As noted in the methods section of this report, only the edible parts of individual fish, oysters and crabs were analyzed, except for fish livers which were composites of several livers. A complete listing of the resulting data is given in Appendix B. The data for fish, oyster, and crab edible tissue is averaged for each of the four sampling sites in Tables 5.1 and 5.2, which also gives an overall average for each tissue type across the whole bay. This same information is presented as bar graphs in Figures 5.1 to 5.20. The average fish tissue and liver values are indicated as a line and the overall site average line is labeled. These averaged data can be compared to averaged data from other estuaries to get an overall impression of the trace metal contamination status of Galveston Bay.

When the data are normalized for percent moisture (wet vs dry wt basis), the averaged oyster trace metal concentrations found during GBNEP are very similar to those found during the first five years of the NS&T Program discussed earlier in this report. The only significant difference in the two data sets is the apparently high Ni and Cr and lower Zn in the GBNEP samples. The higher Ni and Cr are almost certainly an artifact caused by the homogenization of the Morgans Point oysters with a stainless steel grinder. Oysters from other GBNEP sites were not subjected to the grinder and are not enriched in Ni and Cr compared to NS&T oysters from Galveston Bay and elsewhere in the Gulf of Mexico. Crabs from Carancahua Reef were also put through the stainless steel blender and they are also enriched in Ni and Cr, confirming the contamination caused by the blender.

Oysters collected at Morgans Point for GBNEP were about four times higher in Hg than those from elsewhere in Galveston Bay and in other Texas Bays (except for Lavaca Bay where known Hg contamination exists). The NS&T Ship Channel site, which is near the Morgans Point site, shows a slight Hg enrichment, so the Morgans Point data might be valid. On the other hand, contamination by the grinding operation which contaminated the oysters with Ni and Cr cannot be ruled out because the crabs from Carancahua were also enriched in Hg.

As was noted in the literature review section of this report, Zn concentrations in oysters collected for NS&T show a relationship to population and industrialization. That relationship is not as clear for the GBNEP data. Morgans Point and Eagle Point oysters are richer in Zn than are those from Hanna Reef, but not those from Carancahua Reef, which is usually considered to be pristine. The Zn concentration in oysters collected for GBNEP is somewhat less than that in oysters from the same areas collected for NS&T. For example, GBNEP oysters from Hanna Reef are about 20% lower in Zn than the NS&T Hanna Reef oysters. The GBNEP Morgans Point site is about halfway between the NS&T Ship Channel and Todd's Dump sites. Oysters from Morgans Point are only a little higher in Zn than those at Todd's Dump and are only about 50% the concentrations found at the Ship Channel, which, however, varied considerably over the 5 year NS&T sampling. Carancahua Reef oysters collected for GBNEP were equal to or enriched in Zn compared to the NS&T oysters from nearby Confederate Reef. No obvious seasonal effect is evident when comparing the GBNEP and NS&T Zn in

oyster data; however, it seems likely that Zn contamination at the sites varies over fairly short time (weeks) and distance (100s of meters) scales and that this variation is reflected in the Zn content of oysters. No other metal shows such variations as clearly.

From the discussion above it is obvious that interpretation of data on trace metals in oyster tissues is not straightforward. Unfortunately, trace metal data in other organisms is even harder to interpret. Oysters, in contrast to fish, crabs, shrimp, etc. must stay in one place, are easy to identify and collect in large numbers, and are good accumulators of added trace metals. Fish, like oyster, are eaten by man, but it is difficult to collect a large enough number of a given species at a given location to be sure of having a statistically valid sample. Also fish do not accumulate most trace metals to the extent oysters do, as can be seen by the concentrations in Table 5.1 and by literature values (e.g., Eisler, 1981). Because fish do not accumulate most trace metals readily, they do not readily respond to added trace metals in the environment. For example, Jenkins *et al.* (1982) collected benthic fish near, and at some distance from, a major southern California sewage outfall, but could find little difference in trace metal concentrations in the fish flesh. This result occurred in spite of sediment concentrations hundreds of times higher near the outfall. A similar conclusion was reached by Ginn and Barrick (1988) who studied areas near and far from industrialized embayments in Puget Sound.

Based on the literature discussed above, no strong relationship between trace metals in fish flesh and proximity to industrialization was expected for the GBNEP samples and none was found. To be sure, isolated trace metal values several times higher than average can be seen when the data is plotted as in Figures 5.1 to Figure 5.20. For example, a high As value was found in a catfish from Morgans Point, high Hg in a jackfish from Eagle Point and high Pb in a black drum from Hanna Reef. No significance can be attached to these isolated high values until more data are available.

The trace metal concentrations in fish tissue averaged for each site show little variation from place to place in Galveston Bay (Table 5.1). Furthermore, the averaged values are generally less than those for fish from Puget Sound as reported by Ginn and Barrick (1988) or from Southern California as reported by Jenkins *et al.* (1982). Thus, no localized metal pollution is evident from the fish data.

Fish livers are generally much higher in trace metals (except for Hg) than are fish tissues, as can be seen in Figures 5.1 to Figures 5.20, and are highly variable from species to species and from place to place. For example, Ag values several fold higher than average were found in a mullet from Morgans Point, sheepsheads from Eagle Point and Carancahua and a black drum from Carancahua. Very high As was found in a shark liver from Carancahua and very high Cd in a sheepshead from the same location. A mullet liver from Morgans Point was more than 10 times higher than average in Cu. What do these isolated anomalous values mean? Only that individual fish vary in their

response to trace metals in the environment and probably in their exposure history.

This observation is confirmed by the trace metal in fish liver data being collected by the NOAA "Benthic Surveillance" program (NOAA, 1987). The 1984 data for this program shows the same ten-fold or more variability shown by the GBNEP data. A mullet collected at Morgans Point for GBNEP had higher liver Cu and Se than any sample collected for NOAA in 1984, but for other metals several of the NOAA samples were higher than any of the GBNEP samples. The NOAA program is continuing to provide data and to look for links between fish liver trace metals and activities of man (pollution), but the task is not easy.

For several metals, concentrations in crab tissue are intermediate between that in fish muscle and oyster tissue. Very high Ag, higher than that in any other organism, was found in crabs from Carancahua Reef. Cd was high in crabs from Hanna Reef, and Ni and Cr were high at Carancahua Reef. The Ni and Cr are almost certainly artifacts due to sample preparation (grinding in a stainless steel blender) but we have no explanation for the other high values. As with isolated high trace metals in fish, the values in crabs could be due to either differences in accumulating ability by different individual organism and/or individual organism's different exposure histories.

Table 5.1 Galveston Bay National Estuary Program Average 1991 Trace Metal Data. All Values ppm ($\mu\text{g/g}$) Wet Weight.

METALS	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Selenium	Silver	Zinc
GBHR Fish	0.224	0.0043	0.018	0.221	0.100	0.01	0.03	0.56	0.000	4.00
GBMP Fish	0.859	0.0030	0.012	0.223	0.125	0.02	0.01	0.46	0.000	5.99
GBEP Fish	0.333	0.0018	0.006	0.214	0.117	0.00	0.01	0.53	0.000	3.75
GBCR Fish	0.685	0.0031	0.015	0.212	0.098	0.01	0.01	0.58	0.000	4.58
Average Fish	0.525	0.003	0.013	0.218	0.110	0.009	0.016	0.532	0.000	4.581
GBHR Oysters	0.687	0.5180	0.073	29.766	0.008	0.17	0.08	0.43	0.374	306.95
GBMP Oysters	0.771	0.812	1.009	20.03	0.045	0.95	0.11	0.33	0.232	476.82
GBEP Oysters	0.773	0.6010	0.052	32.268	0.010	0.16	0.11	0.38	0.410	417.34
GBCR Oysters	0.767	0.9060	0.089	58.126	0.017	0.31	0.18	0.63	0.106	494.00
Average Oyster	0.750	0.709	0.306	35.048	0.020	0.399	0.119	0.441	0.281	423.779
GBHR Crabs	0.361	0.0460	0.031	4.779	0.021	0.16	0.03	0.42	0.056	29.31
GBMP Crabs	0.234	0.0420	0.014	11.378	0.034	0.10	0.02	0.58	0.125	34.48
GBEP Crabs	0.161	0.0140	0.027	8.814	0.027	0.01	0.02	0.53	0.082	37.24
GBCR Crabs	0.807	0.1200	0.663	11.914	0.078	0.41	0.03	0.48	0.424	34.20
Average Crab	0.391	0.056	0.184	9.221	0.040	0.170	0.023	0.501	0.172	33.808

SITE		TRACE METALS														
Tissue Type Fish Type	n	Silver (Ag) (ppm)			Arsenic (As) (ppm)			Cadmium (Cd) (ppm)			Chromium (Cr) (ppm)			Copper (Cu) (ppm)		
		Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Morgans Point (MP)	67	0.14	0.00	3.45	0.70	0.02	16.49	0.236	0.000	1.603	0.211	0.000	3.206	33.819	0.080	1605.800
Blue Crab	11	0.13	0.05	0.33	0.23	0.07	0.45	0.042	0.007	0.089	0.014	0.000	0.042	11.378	5.298	19.586
Virginia Oyster	12	0.23	0.07	0.38	0.77	0.38	1.56	0.812	0.658	1.045	1.088	0.097	3.206	20.000	9.300	31.600
Fish Tissue	30	0.00	0.00	0.00	0.86	0.02	16.49	0.003	0.000	0.039	0.012	0.000	0.038	0.223	0.080	0.414
Blackdrum	6	0.00	0.00	0.00	0.21	0.14	0.34	0.002	0.001	0.005	0.016	0.009	0.023	0.205	0.093	0.319
Hardhead Catfish	11	0.00	0.00	0.00	1.98	0.02	16.49	0.005	0.001	0.039	0.008	0.000	0.028	0.279	0.180	0.369
Reddrum	8	0.00	0.00	0.00	0.14	0.04	0.43	0.001	0.000	0.003	0.021	0.000	0.038	0.212	0.105	0.414
Southern Flounder	3	0.00	0.00	0.00	0.38	0.29	0.47	0.001	0.000	0.002	0.006	0.000	0.018	0.172	0.098	0.256
Striped Mullet	2	0.00	0.00	0.00	0.25	0.18	0.31	0.002	0.001	0.002	0.000	0.000	0.000	0.094	0.080	0.109
Fish Liver	14	0.36	0.00	3.45	0.67	0.07	3.09	0.396	0.101	1.603	0.042	0.000	0.164	135.286	2.500	1605.800
Blackdrum	3	0.15	0.06	0.25	0.61	0.35	0.86	0.631	0.475	0.923	0.062	0.000	0.164	18.800	16.200	22.000
Hardhead Catfish	5	0.22	0.01	0.50	0.74	0.07	3.09	0.246	0.101	0.441	0.014	0.000	0.027	39.700	2.500	111.400
Reddrum	4	0.01	0.00	0.02	0.53	0.24	0.76	0.174	0.149	0.223	0.028	0.017	0.041	5.200	3.700	6.700
Southern Flounder	1	0.02	0.02	0.02	0.74	0.74	0.74	0.125	0.125	0.125	0.134	0.134	0.134	12.500	12.500	12.500
Striped Mullet	1	3.45	3.45	3.45	1.05	1.05	1.05	1.603	1.603	1.603	0.086	0.086	0.086	1605.800	1605.800	1605.800
Eagle Point (EP)	63	0.11	0.00	0.62	0.48	0.03	3.26	0.168	0.000	0.992	0.022	0.000	0.120	13.021	0.089	191.100
Blue Crab	10	0.08	0.04	0.16	0.16	0.05	0.33	0.014	0.006	0.026	0.027	0.000	0.049	8.814	3.700	13.869
Virginia Oyster	11	0.41	0.20	0.62	0.77	0.53	1.08	0.601	0.387	0.779	0.052	0.031	0.085	32.268	12.021	66.486
Fish Tissue	30	0.00	0.00	0.00	0.33	0.03	1.14	0.001	0.000	0.005	0.006	0.000	0.029	0.214	0.089	0.512
Blackdrum	8	0.00	0.00	0.00	0.36	0.06	0.79	0.002	0.000	0.005	0.007	0.000	0.026	0.237	0.144	0.512
Crevalle Jack	1	0.00	0.00	0.00	0.23	0.23	0.23	0.001	0.001	0.001	0.000	0.000	0.000	0.217	0.217	0.217
Flounder	1	0.00	0.00	0.00	0.27	0.27	0.27	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.100	0.100
Hardhead Catfish	3	0.00	0.00	0.00	0.28	0.08	0.51	0.001	0.000	0.001	0.011	0.000	0.019	0.295	0.210	0.439
Reddrum	3	0.00	0.00	0.00	0.32	0.26	0.38	0.002	0.000	0.005	0.019	0.000	0.029	0.189	0.109	0.232
Sheepshead	3	0.00	0.00	0.00	0.58	0.24	1.05	0.001	0.000	0.001	0.007	0.000	0.021	0.160	0.134	0.201
Southern Flounder	5	0.00	0.00	0.00	0.33	0.03	1.14	0.001	0.001	0.001	0.005	0.000	0.015	0.195	0.095	0.292
Spotted Seatrout	6	0.00	0.00	0.00	0.23	0.08	0.45	0.001	0.000	0.004	0.000	0.000	0.000	0.218	0.089	0.490
Fish Liver	12	0.11	0.00	0.54	0.84	0.22	3.26	0.318	0.045	0.992	0.028	0.000	0.120	30.900	2.500	191.100
Blackdrum	3	0.21	0.04	0.47	0.76	0.55	1.19	0.622	0.242	0.992	0.026	0.000	0.046	32.200	18.800	46.800
Crevalle Jack	1	0.01	0.01	0.01	0.85	0.85	0.85	0.411	0.411	0.411	0.036	0.036	0.036	5.400	5.400	5.400
Flounder	2	0.04	0.02	0.06	1.01	0.69	1.33	0.196	0.173	0.219	0.035	0.031	0.038	25.800	22.600	29.100
Hardhead Catfish	1	0.00	0.00	0.00	0.22	0.22	0.22	0.209	0.209	0.209	0.000	0.000	0.000	2.500	2.500	2.500
Reddrum	1	0.02	0.02	0.02	0.54	0.54	0.54	0.062	0.062	0.062	0.028	0.028	0.028	5.900	5.900	5.900
Sheepshead	1	0.54	0.54	0.54	3.26	3.26	3.26	0.603	0.603	0.603	0.000	0.000	0.000	191.100	191.100	191.100
Spotted Seatrout	3	0.02	0.00	0.03	0.32	0.28	0.36	0.089	0.045	0.121	0.040	0.000	0.120	5.900	4.000	8.600

Table 5.2 Summary of Trace Metal Concentrations (dry weight)

SITE		TRACE METALS														
Tissue Type Fish Type	n	Silver (Ag) (ppm)			Arsenic (As) (ppm)			Cadmium (Cd) (ppm)			Chromium (Cr) (ppm)			Copper (Cu) (ppm)		
		Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Hanna Reef (HR)	64	0.09	0.00	0.94	0.45	0.05	2.72	0.216	0.000	1.001	0.091	0.000	3.000	9.888	0.078	85.940
Blue Crab	11	0.06	0.03	0.09	0.36	0.22	0.50	0.459	0.009	0.122	0.031	0.011	0.072	4.779	2.561	8.870
Virginia Oyster	10	0.37	0.21	0.94	0.69	0.32	1.34	0.518	0.383	0.724	0.073	0.029	0.199	29.770	12.820	85.940
Fish Tissue	30	0.00	0.00	0.00	0.23	0.05	0.59	0.004	0.000	0.063	0.018	0.000	0.087	0.222	0.078	0.872
Atlantic Croaker	2	0.00	0.00	0.00	0.38	0.32	0.43	0.002	0.002	0.002	0.000	0.000	0.000	0.173	0.142	0.204
Blackdrum	4	0.00	0.00	0.00	0.46	0.16	0.59	0.005	0.003	0.007	0.044	0.011	0.087	0.432	0.125	0.872
Flounder	2	0.00	0.00	0.00	0.14	0.11	0.17	0.002	0.001	0.002	0.000	0.000	0.000	0.094	0.093	0.095
Reddrum	4	0.00	0.00	0.00	0.22	0.16	0.30	0.019	0.001	0.063	0.028	0.010	0.071	0.263	0.191	0.351
Southern Flounder	8	0.00	0.00	0.00	0.25	0.09	0.42	0.002	0.000	0.004	0.008	0.000	0.027	0.169	0.078	0.326
Spotted Seatrout	10	0.00	0.00	0.00	0.10	0.05	0.16	0.001	0.000	0.004	0.018	0.000	0.070	0.198	0.124	0.341
Fish Liver	13	0.09	0.01	0.32	0.84	0.26	2.72	0.265	0.087	1.001	0.327	0.000	3.000	21.223	5.400	59.000
Atlantic Croaker	1	0.25	0.25	0.25	2.72	2.72	2.72	0.467	0.467	0.467	0.044	0.044	0.044	59.000	59.000	59.000
Blackdrum	2	0.23	0.13	0.32	0.77	0.41	1.12	0.721	0.441	1.001	0.021	0.016	0.027	25.000	16.100	33.900
Flounder	5	0.05	0.01	0.08	0.57	0.28	0.99	0.182	0.089	0.509	0.812	0.000	3.000	24.700	6.800	39.800
Reddrum	2	0.02	0.02	0.03	0.83	0.79	0.87	0.133	0.109	0.157	0.032	0.000	0.063	6.700	5.400	8.100
Spotted Seatrout	3	0.06	0.05	0.08	0.72	0.26	1.16	0.119	0.087	0.176	0.014	0.000	0.024	10.000	7.400	14.500
Carancahua Reef (CR)	60	0.09	0.00	0.94	0.89	0.12	7.52	0.310	0.000	3.711	0.128	0.000	2.719	16.952	0.088	144.055
Blue Crab	6	0.42	0.21	0.94	0.81	0.61	1.07	0.120	0.059	0.202	0.663	0.113	2.719	11.914	6.080	17.688
Virginia Oyster	10	0.11	0.05	0.45	0.77	0.40	1.13	0.906	0.403	1.710	0.089	0.049	0.177	58.126	15.949	144.055
Fish Tissue	30	0.00	0.00	0.00	0.67	0.26	1.84	0.003	0.000	0.021	0.019	0.000	0.169	0.220	0.088	0.557
Blackdrum	4	0.00	0.00	0.00	1.43	0.89	1.84	0.006	0.002	0.011	0.014	0.000	0.022	0.349	0.137	0.557
Gaftopsail Catfish	1	0.00	0.00	0.00	0.65	0.65	0.65	0.003	0.003	0.003	0.169	0.169	0.169	0.232	0.232	0.232
Hardhead Catfish	6	0.00	0.00	0.00	0.67	0.51	0.92	0.003	0.001	0.004	0.035	0.000	0.065	0.296	0.224	0.419
Reddrum	7	0.00	0.00	0.00	0.55	0.42	0.65	0.005	0.001	0.021	0.003	0.000	0.013	0.220	0.123	0.410
Shark	1	0.00	0.00	0.00	0.66	0.66	0.66	0.000	0.000	0.000	0.000	0.000	0.000	0.261	0.261	0.261
Sheepshead	1	0.00	0.00	0.00	0.26	0.26	0.26	0.004	0.004	0.004	0.043	0.043	0.043	0.140	0.140	0.140
Southern Flounder	10	0.00	0.00	0.00	0.50	0.32	0.71	0.001	0.000	0.003	0.007	0.000	0.025	0.126	0.088	0.208
Fish Liver	14	0.11	0.00	0.42	1.46	0.12	7.52	0.625	0.008	3.711	0.160	0.000	2.000	25.557	0.800	76.100
Blackdrum	2	0.37	0.32	0.42	1.37	0.95	1.78	1.339	1.151	1.526	0.019	0.018	0.021	26.600	25.600	27.700
Gaftopsail Catfish	1	0.04	0.04	0.04	0.35	0.35	0.35	0.220	0.220	0.220	0.000	0.000	0.000	3.100	3.100	3.100
Hardhead Catfish	1	0.01	0.01	0.01	0.12	0.12	0.12	0.112	0.112	0.112	0.042	0.042	0.042	3.200	3.200	3.200
Reddrum	3	0.04	0.02	0.07	1.03	0.81	1.23	0.283	0.103	0.630	0.022	0.000	0.034	7.300	5.900	8.400
Shark	1	0.00	0.00	0.00	7.52	7.52	7.52	0.008	0.008	0.008	0.029	0.029	0.029	0.800	0.800	0.800
Sheepshead	1	0.39	0.39	0.39	1.97	1.97	1.97	3.711	3.711	3.711	0.021	0.021	0.021	76.100	76.100	76.100
Southern Flounder	5	0.06	0.04	0.08	0.92	0.75	1.22	0.233	0.194	0.280	0.410	0.000	2.000	39.900	32.800	53.700

Table 5.2 continued

SITE		TRACE METALS														
Tissue Type Fish Type	n	Mercury (Hg) (ppm)			Nickel (Ni) (ppm)			Lead (Pb) (ppm)			Selenium (Se) (ppm)			Zinc (Zn) (ppm)		
		Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Morgans Point (MP)	67	0.123	0.010	0.474	0.20	0.00	2.07	0.05	0.00	0.29	2.27	0.03	88.98	115.2	2.6	592.7
Blue Crab	11	0.034	0.010	0.090	0.01	0.00	0.03	0.02	0.00	0.06	0.57	0.30	0.93	34.5	15.6	46.3
Virginia Oyster	12	0.045	0.012	0.132	0.96	0.30	2.07	0.11	0.08	0.15	0.33	0.03	0.61	476.8	246.9	592.7
Fish Tissue	30	0.125	0.011	0.440	0.02	0.00	0.33	0.01	0.00	0.08	0.46	0.22	0.79	6.0	2.6	17.1
Blackdrum	6	0.063	0.028	0.090	0.00	0.00	0.00	0.00	0.00	0.02	0.66	0.49	0.79	3.6	2.8	4.5
Hardhead Catfish	11	0.167	0.090	0.238	0.00	0.00	0.00	0.01	0.00	0.08	0.30	0.22	0.35	9.8	6.1	17.1
Reddrum	8	0.170	0.108	0.440	0.06	0.00	0.33	0.01	0.00	0.04	0.54	0.46	0.70	3.8	3.1	5.0
Southern Flounder	3	0.049	0.044	0.056	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.38	0.55	4.6	3.7	5.8
Striped Mullet	2	0.015	0.011	0.019	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.32	0.57	3.0	2.6	3.4
Fish Liver	14	0.258	0.078	0.474	0.10	0.00	0.87	0.11	0.00	0.29	9.14	1.89	88.98	102.9	25.9	310.9
Blackdrum	3	0.137	0.093	0.184	0.35	0.06	0.87	0.14	0.11	0.18	2.84	2.29	3.34	37.9	27.4	45.9
Hardhead Catfish	5	0.357	0.224	0.474	0.00	0.00	0.00	0.19	0.11	0.29	3.33	2.05	4.58	202.1	41.0	310.9
Reddrum	4	0.241	0.176	0.297	0.00	0.00	0.00	0.03	0.00	0.05	2.97	2.07	4.05	28.8	25.9	33.8
Southern Flounder	1	0.078	0.078	0.078	0.00	0.00	0.00	0.00	0.00	0.00	1.89	1.89	1.84	77.3	77.3	77.3
Striped Mullet	1	0.370	0.370	0.370	0.38	0.38	0.38	0.09	0.09	0.09	88.98	88.98	88.98	123.4	123.4	123.4
Eagle Point (EP)	63	0.110	0.007	1.269	0.04	0.00	0.27	0.04	0.00	0.19	0.95	0.09	4.11	94.5	2.6	735.3
Blue Crab	10	0.027	0.010	0.053	0.01	0.00	0.03	0.02	0.00	0.05	0.53	0.25	0.84	37.2	13.7	66.1
Virginia Oyster	11	0.010	0.007	0.015	0.16	0.10	0.27	0.11	0.07	0.16	0.38	0.19	0.54	417.3	229.3	735.3
Fish Tissue	30	0.117	0.032	0.900	0.00	0.00	0.03	0.01	0.00	0.12	0.53	0.09	0.87	3.7	2.6	7.3
Blackdrum	8	0.088	0.032	0.286	0.01	0.00	0.03	0.00	0.00	0.03	0.57	0.09	0.87	3.7	3.3	4.7
Creville Jack	1	0.900	0.900	0.900	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.62	0.62	3.5	3.5	3.5
Flounder	1	0.036	0.036	0.036	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.46	0.46	3.4	3.4	3.4
Hardhead Catfish	3	0.109	0.041	0.178	0.01	0.00	0.03	0.01	0.00	0.04	0.59	0.49	0.68	4.1	3.3	4.6
Reddrum	3	0.052	0.044	0.065	0.01	0.00	0.02	0.00	0.00	0.00	0.52	0.45	0.56	3.4	3.2	3.7
Sheepshead	3	0.081	0.041	0.126	0.00	0.00	0.00	0.01	0.00	0.02	0.61	0.58	0.67	3.5	3.1	4.2
Southern Flounder	5	0.094	0.035	0.246	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.15	0.56	3.9	2.6	7.3
Spotted Seatrout	6	0.111	0.042	0.298	0.00	0.00	0.00	0.03	0.00	0.12	0.49	0.18	0.64	3.8	2.6	5.3
Fish Liver	12	0.256	0.041	1.269	0.04	0.00	0.21	0.06	0.00	0.19	2.84	1.33	4.11	73.3	26.9	287.7
Blackdrum	3	0.176	0.137	0.209	0.10	0.00	0.21	0.15	0.13	0.19	3.60	3.19	4.11	46.6	41.0	51.2
Creville Jack	1	0.505	0.505	0.505	0.04	0.04	0.04	0.00	0.00	0.00	2.91	2.91	2.91	54.3	54.3	54.3
Flounder	2	0.069	0.067	0.071	0.00	0.00	0.00	0.00	0.00	0.00	1.84	1.33	2.34	64.2	63.8	64.5
Hardhead Catfish	1	1.269	1.269	1.269	0.00	0.00	0.00	0.14	0.14	0.14	1.92	1.92	1.92	116.6	116.6	116.6
Reddrum	1	0.115	0.115	0.115	0.02	0.02	0.02	0.00	0.00	0.00	3.27	3.27	3.27	33.4	33.4	33.4
Sheepshead	1	0.243	0.243	0.243	0.05	0.05	0.05	0.07	0.07	0.07	3.63	3.63	3.63	287.7	287.7	287.7
Spotted Seatrout	3	0.093	0.041	0.128	0.02	0.00	0.05	0.03	0.00	0.05	2.62	2.00	2.93	39.6	26.9	61.0

Table 5.2 continued

SITE		TRACE METALS														
Tissue Type Fish Type	n	Mercury (Hg) (ppm)			Nickel (Ni) (ppm)			Lead (Pb) (ppm)			Selenium (Se) (ppm)			Zinc (Zn) (ppm)		
		Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Hanna Reef (HR)	64	0.079	0.005	0.298	0.06	0.00	0.96	0.04	0.00	0.43	0.88	0.21	4.94	68.7	2.8	768.7
Blue Crab	11	0.021	0.010	0.033	0.13	0.00	0.96	0.02	0.00	0.06	0.42	0.28	0.56	29.3	14.2	50.6
Virginia Oyster	10	0.008	0.005	0.013	0.17	0.11	0.26	0.08	0.04	0.13	0.43	0.21	0.87	307.0	103.4	768.7
Fish Tissue	30	0.100	0.030	0.298	0.01	0.00	0.04	0.03	0.00	0.43	0.56	0.35	0.95	4.0	2.8	8.9
Atlantic Croaker	2	0.049	0.049	0.050	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.76	0.93	3.8	3.6	4.1
Blackdrum	4	0.066	0.040	0.086	0.02	0.00	0.04	0.12	0.00	0.43	0.75	0.55	0.95	4.9	2.8	8.9
Flounder	2	0.034	0.030	0.038	0.02	0.02	0.02	0.01	0.00	0.02	0.43	0.40	0.46	4.3	3.6	5.0
Reddrum	4	0.067	0.041	0.089	0.02	0.00	0.04	0.04	0.00	0.13	0.53	0.46	0.67	4.0	2.9	5.3
Southern Flounder	8	0.055	0.037	0.083	0.01	0.00	0.03	0.04	0.00	0.29	0.49	0.40	0.75	3.8	3.2	5.5
Spotted Seatrout	10	0.186	0.061	0.298	0.00	0.00	0.02	0.00	0.00	0.00	0.51	0.35	0.61	3.8	2.8	7.4
Fish Liver	13	0.135	0.046	0.237	0.02	0.00	0.15	0.05	0.00	0.17	2.36	1.11	4.94	68.0	31.3	150.3
Atlantic Croaker	1	0.213	0.213	0.213	0.04	0.04	0.04	0.05	0.05	0.05	4.74	4.74	4.74	52.0	52.0	52.0
Blackdrum	2	0.211	0.184	0.237	0.09	0.04	0.15	0.17	0.16	0.17	3.91	2.89	4.94	44.6	36.1	53.0
Flounder	5	0.069	0.046	0.128	0.00	0.00	0.00	0.01	0.00	0.03	1.80	1.61	2.02	109.2	32.5	150.3
Reddrum	2	0.131	0.116	0.146	0.00	0.00	0.00	0.03	0.00	0.05	2.32	2.29	2.35	33.5	31.3	35.8
Spotted Seatrout	3	0.172	0.130	0.236	0.00	0.00	0.00	0.04	0.00	0.11	1.50	1.11	2.12	43.3	33.6	51.2
Carancahua Reef (CR)	60	0.095	0.009	0.483	0.11	0.00	1.64	0.06	0.00	0.42	1.21	0.15	11.37	110.9	2.7	922.2
Blue Crab	6	0.078	0.030	0.183	0.41	0.09	1.64	0.03	0.01	0.10	0.48	0.42	0.56	34.2	21.0	48.4
Virginia Oyster	10	0.017	0.009	0.032	0.31	0.13	0.71	0.18	0.07	0.30	0.63	0.35	0.88	494.0	190.1	922.2
Fish Tissue	30	0.093	0.030	0.255	0.01	0.00	0.05	0.01	0.00	0.07	0.59	0.15	1.04	4.5	2.7	13.6
Blackdrum	4	0.073	0.042	0.107	0.03	0.00	0.05	0.02	0.00	0.07	0.87	0.67	1.04	3.6	3.3	4.2
Gaftsosail Catfish	1	0.255	0.255	0.255	0.00	0.00	0.00	0.06	0.06	0.06	0.15	0.15	0.15	9.3	9.3	9.3
Hardhead Catfish	6	0.091	0.044	0.172	0.02	0.00	0.04	0.01	0.00	0.04	0.50	0.30	0.78	7.3	3.7	13.6
Reddrum	7	0.116	0.092	0.141	0.00	0.00	0.03	0.01	0.00	0.06	0.56	0.42	0.77	3.8	3.2	4.5
Shark	1	0.196	0.196	0.196	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.60	0.60	3.3	3.3	3.3
Sheepshead	1	0.095	0.095	0.095	0.00	0.00	0.00	0.03	0.03	0.03	0.48	0.48	0.48	2.7	2.7	2.7
Southern Flounder	10	0.059	0.030	0.089	0.00	0.00	0.02	0.01	0.00	0.03	0.60	0.43	0.69	3.6	3.0	4.2
Fish Liver	14	0.163	0.038	0.483	0.06	0.00	0.24	0.08	0.00	0.42	3.27	1.42	11.37	97.9	4.9	239.5
Blackdrum	2	0.240	0.185	0.295	0.22	0.20	0.24	0.28	0.15	0.42	4.44	4.09	4.78	49.6	48.2	51.0
Gaftsosail Catfish	1	0.238	0.238	0.238	0.04	0.04	0.04	0.18	0.18	0.18	0.26	2.63	2.63	215.0	215.0	215.0
Hardhead Catfish	1	0.219	0.219	0.219	0.00	0.00	0.00	0.03	0.03	0.03	2.80	2.80	2.80	239.5	239.5	239.5
Reddrum	3	0.162	0.070	0.222	0.04	0.03	0.05	0.03	0.00	0.05	2.35	1.42	3.40	30.4	22.9	34.6
Shark	1	0.038	0.038	0.038	0.08	0.08	0.08	0.00	0.00	0.00	11.37	11.37	11.37	4.9	4.9	4.9
Sheepshead	1	0.483	0.483	0.483	0.10	0.10	0.10	0.30	0.30	0.30	3.48	3.48	3.48	155.8	155.8	155.8
Southern Flounder	5	0.067	0.048	0.084	0.00	0.00	0.00	0.00	0.00	0.00	2.39	1.51	5.22	113.0	68.7	169.4

Table 5.2 continued

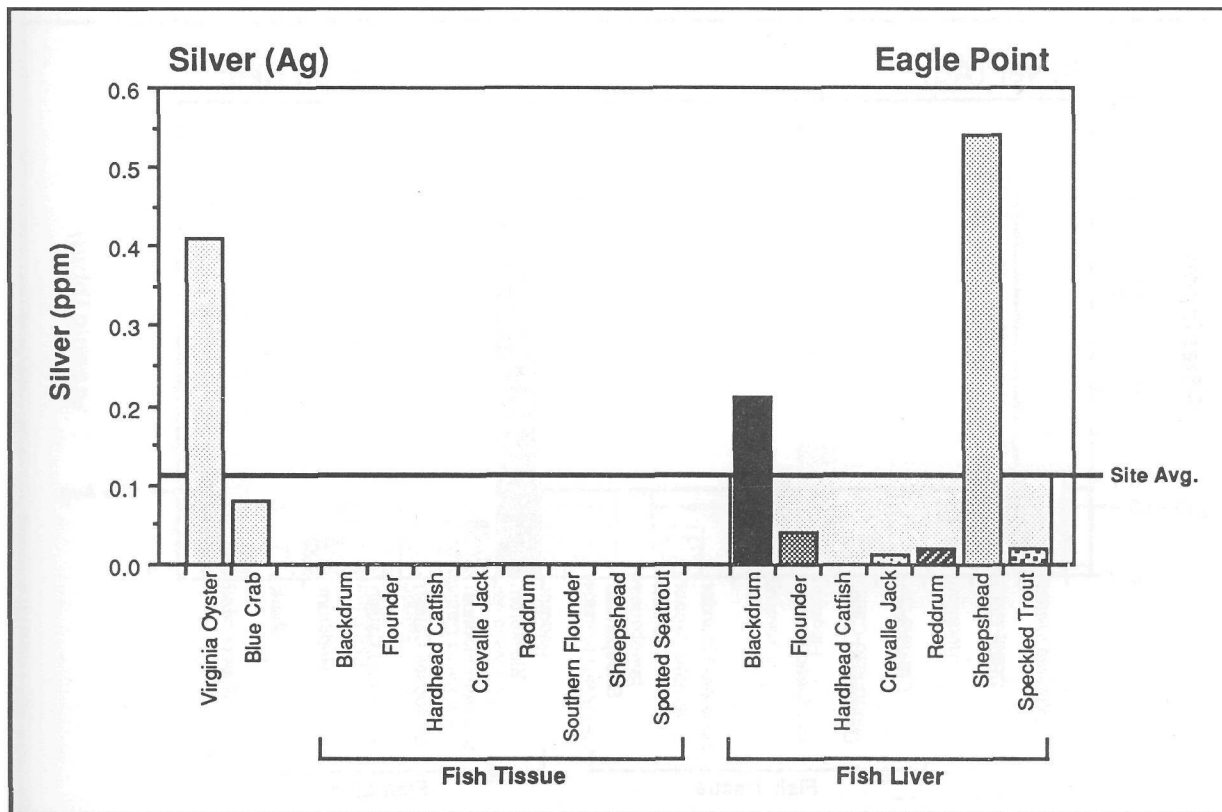
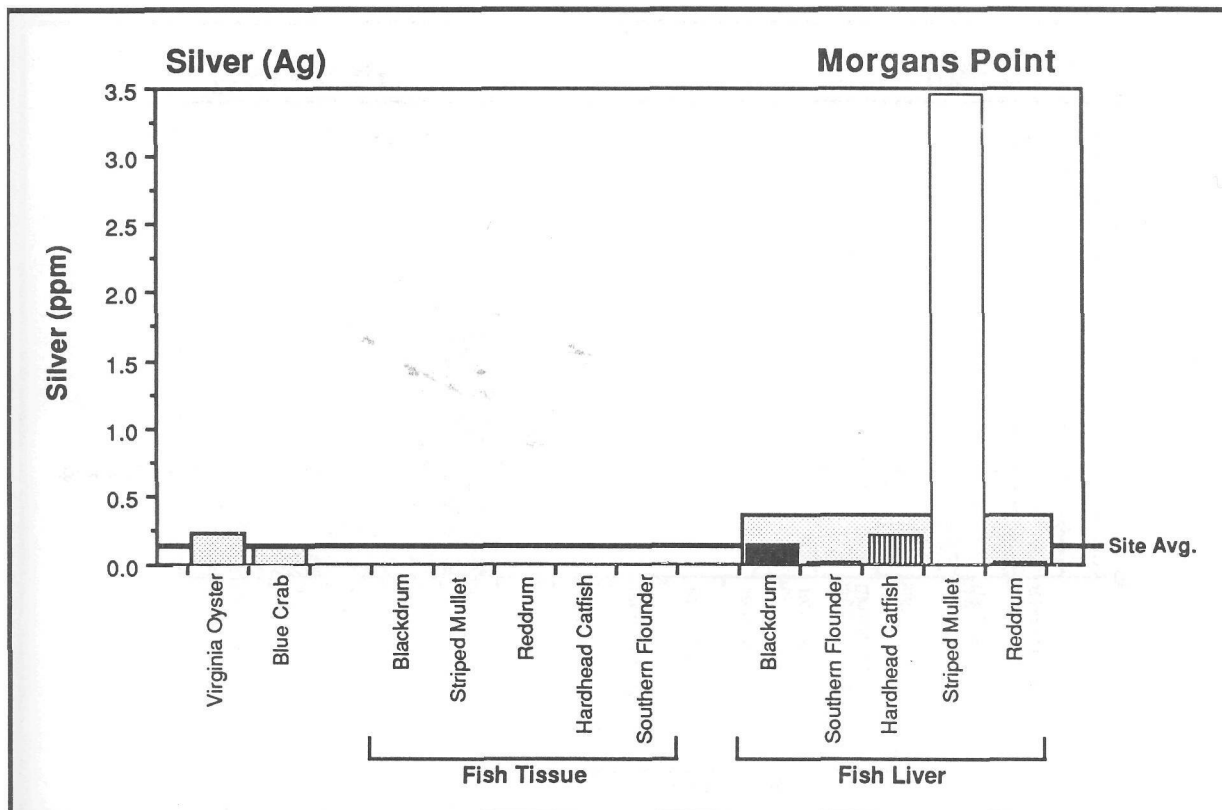


Figure 5.1. Silver concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Morgans Point and Eagle Point.

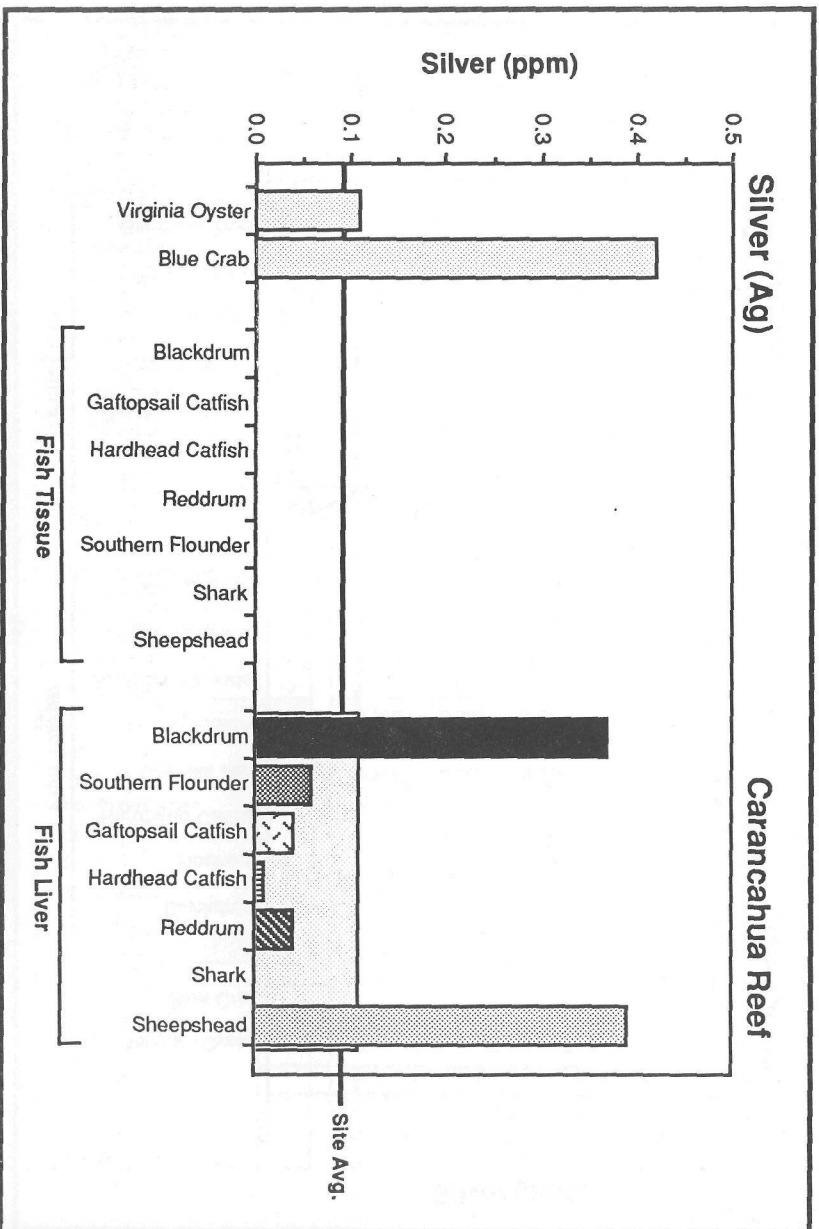
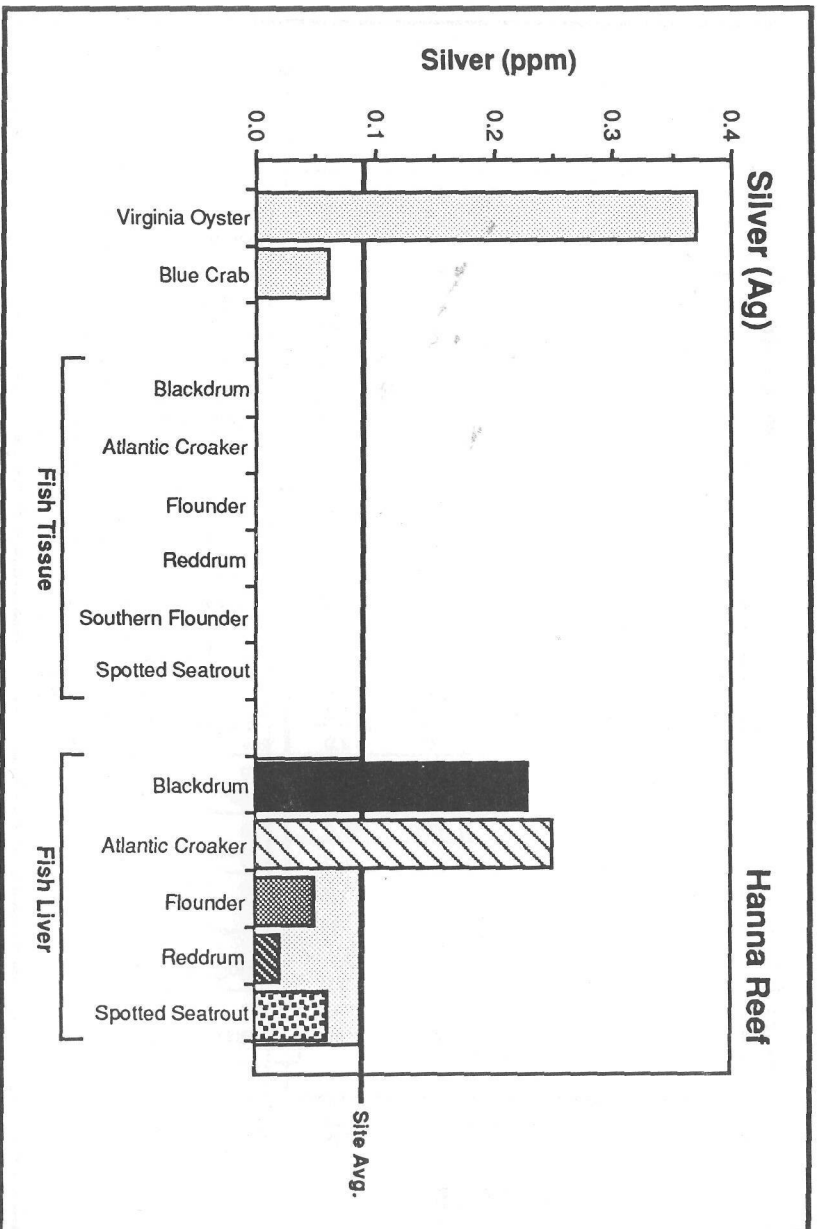


Figure 5.2. Silver concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Hanna Reef and Carancagua Reef.

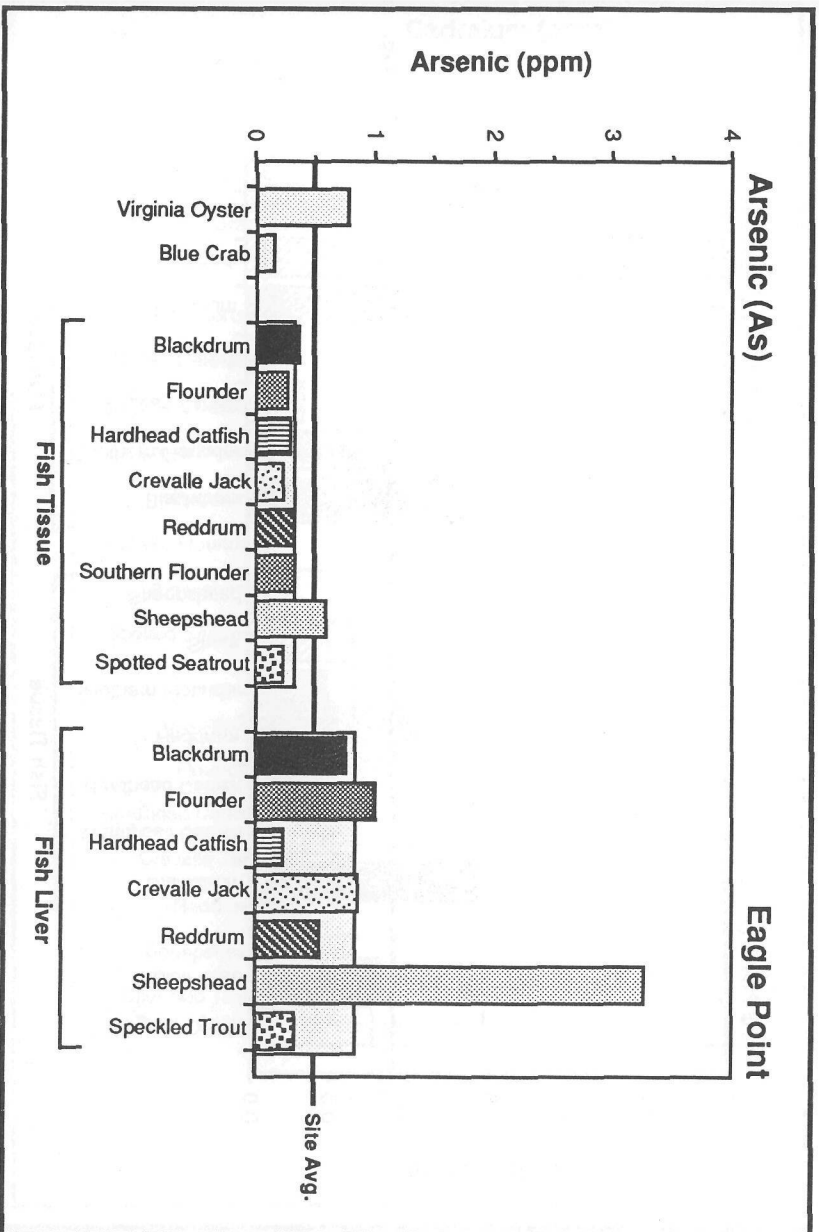
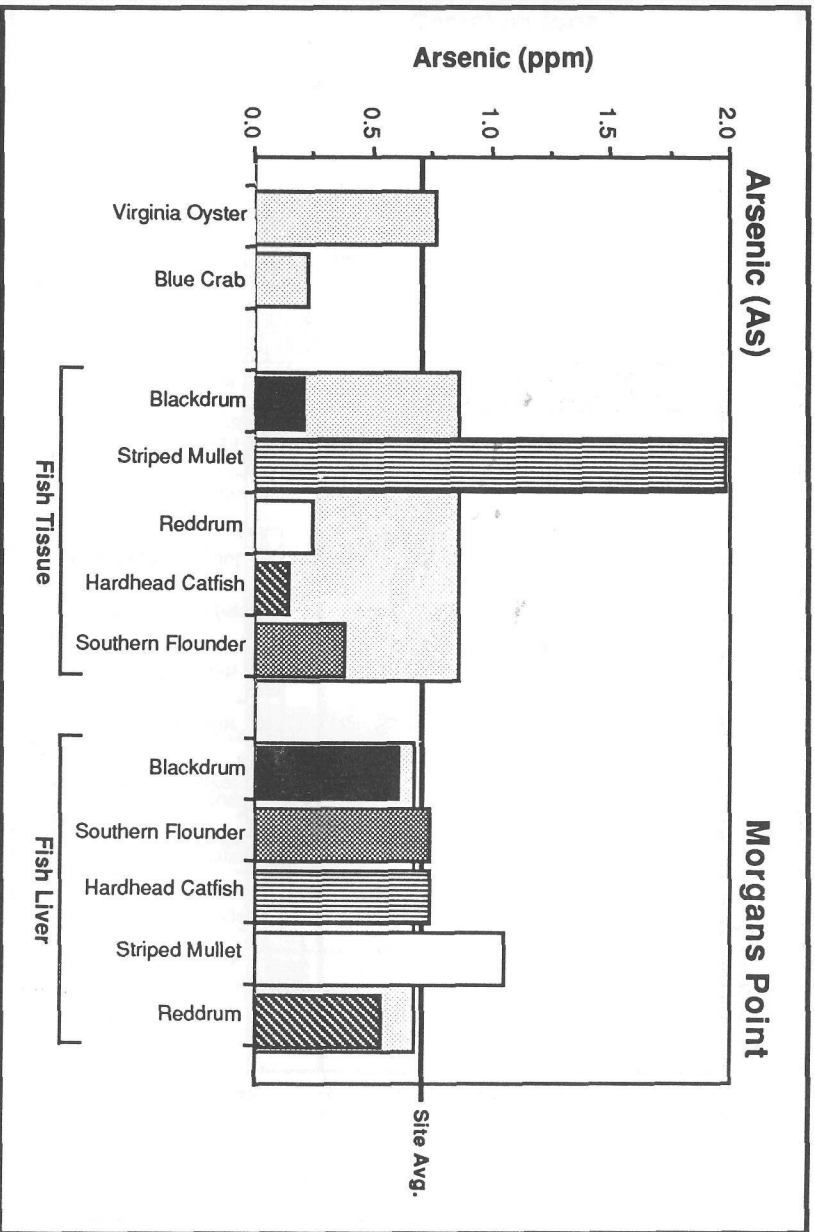


Figure 5.3. Arsenic concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Morgans Point and Eagle Point.

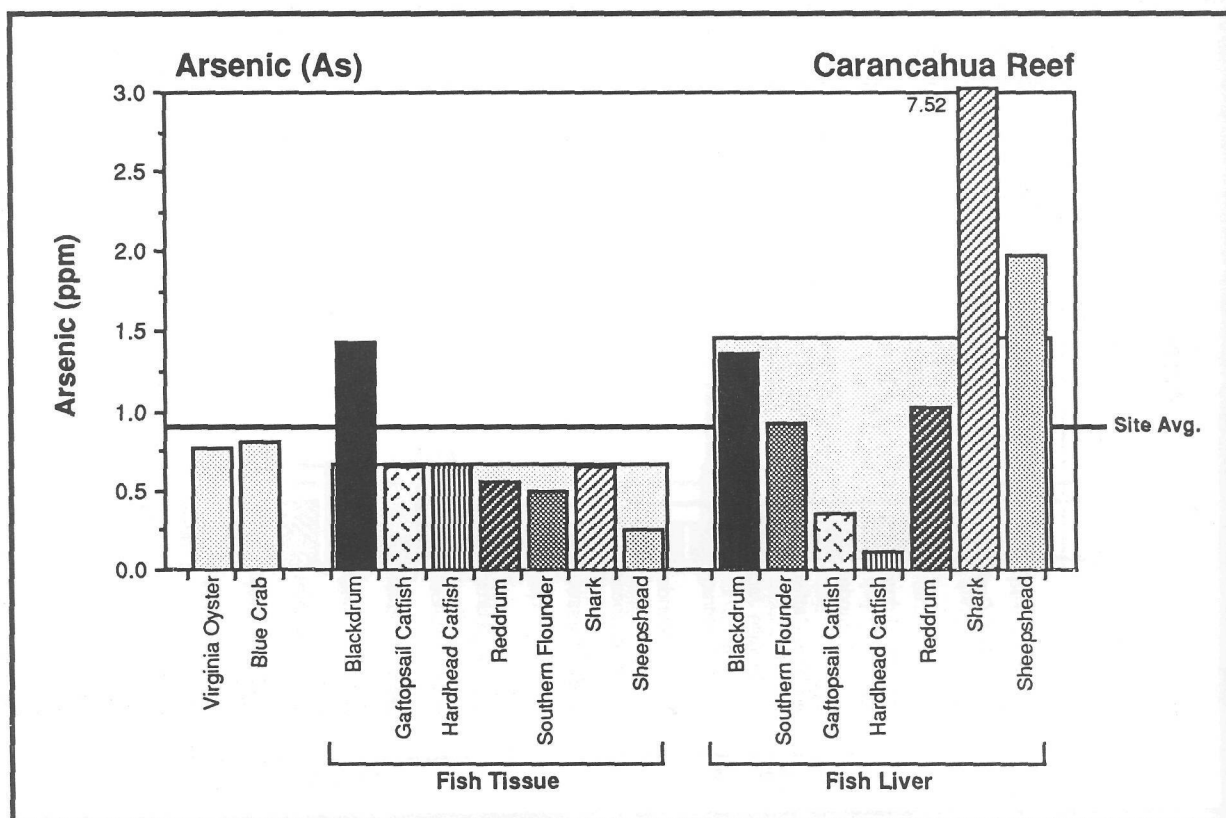
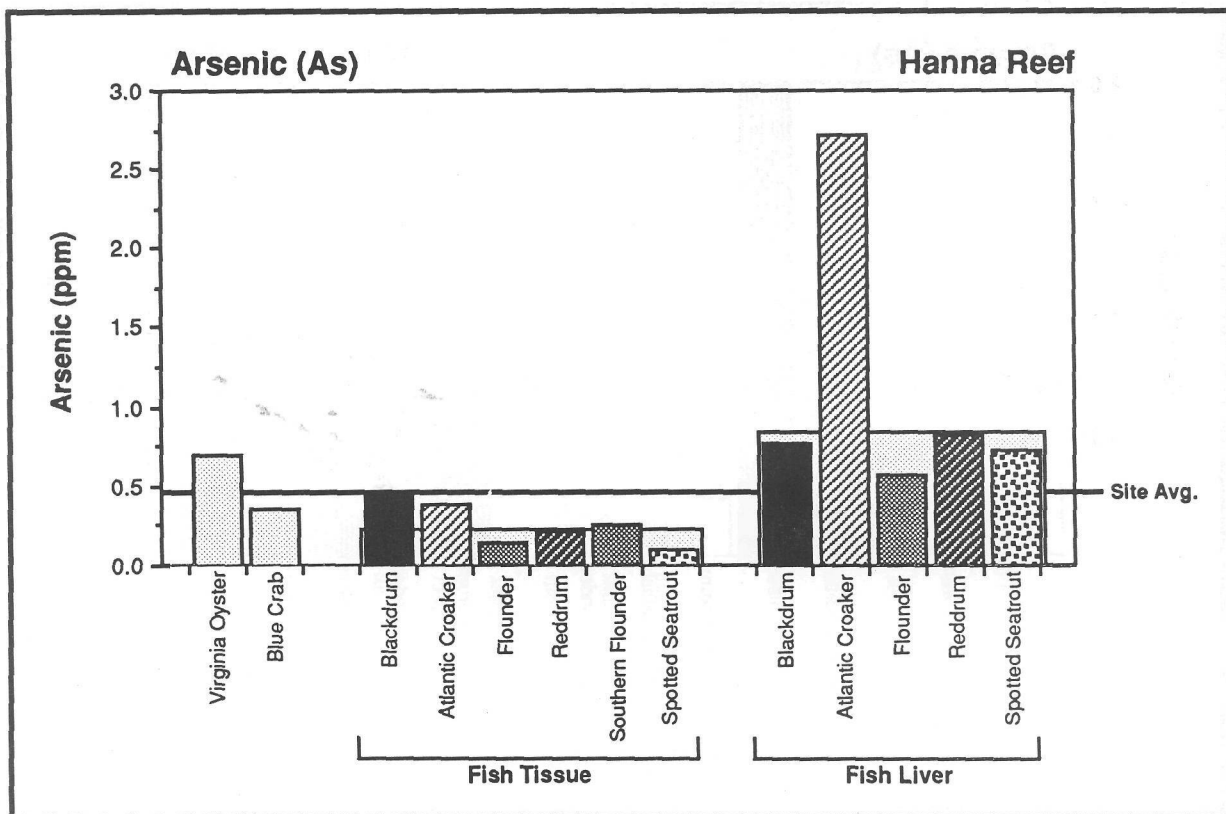


Figure 5.4. Arsenic concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Hanna Reef and Carancahua Reef.

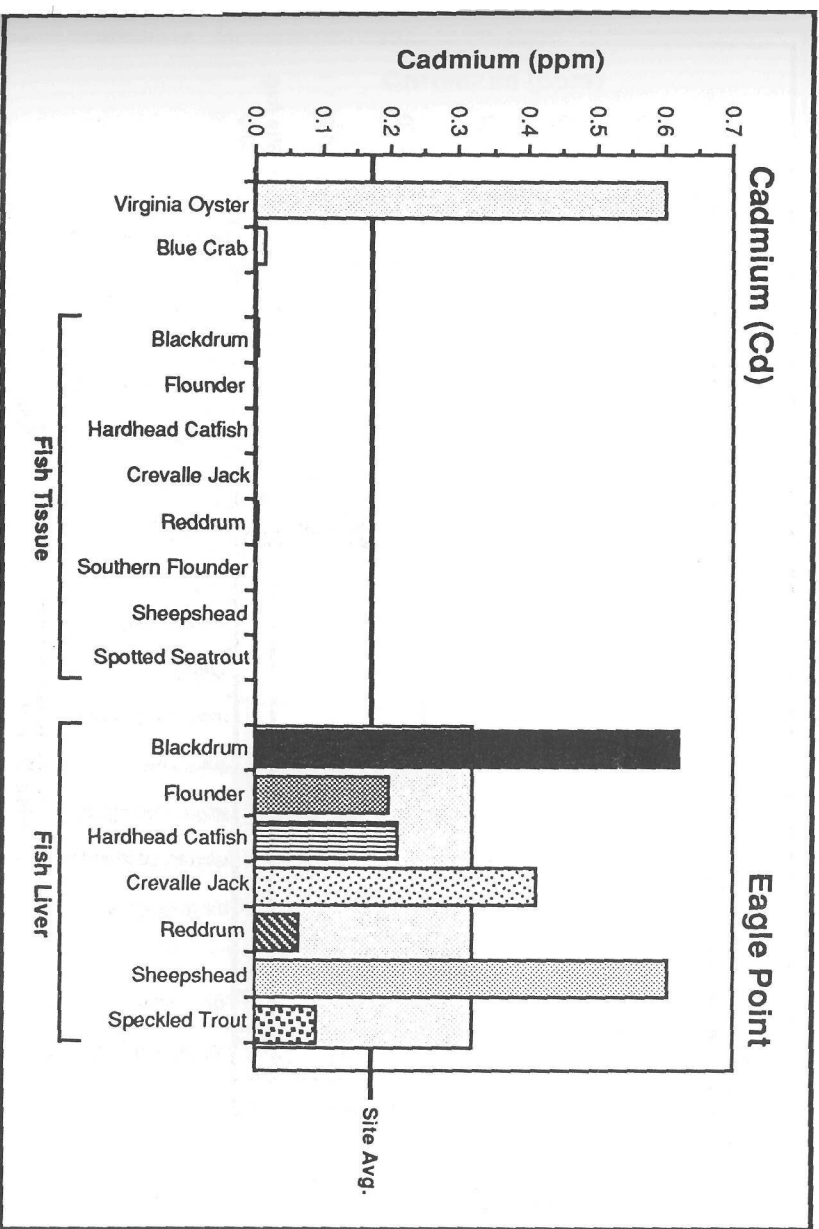
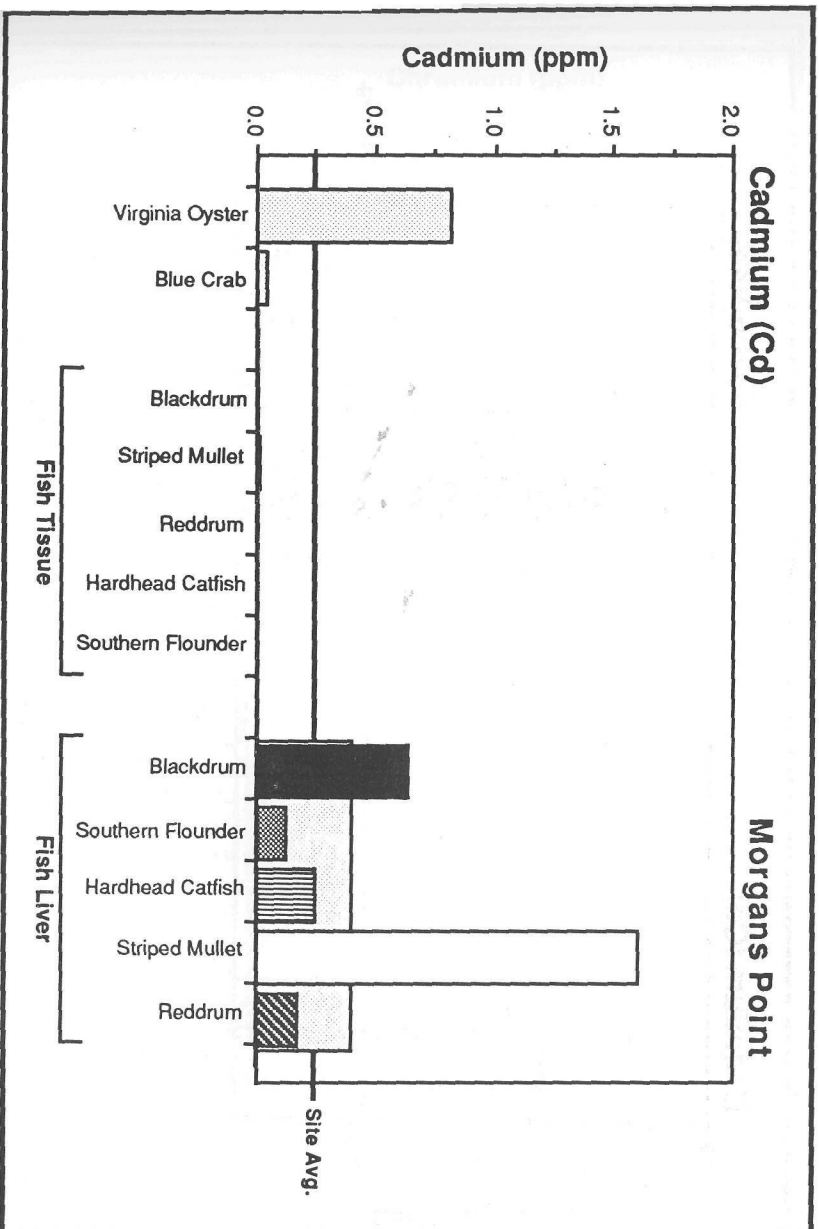


Figure 5.5. Cadmium concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Morgans Point and Eagle Point.

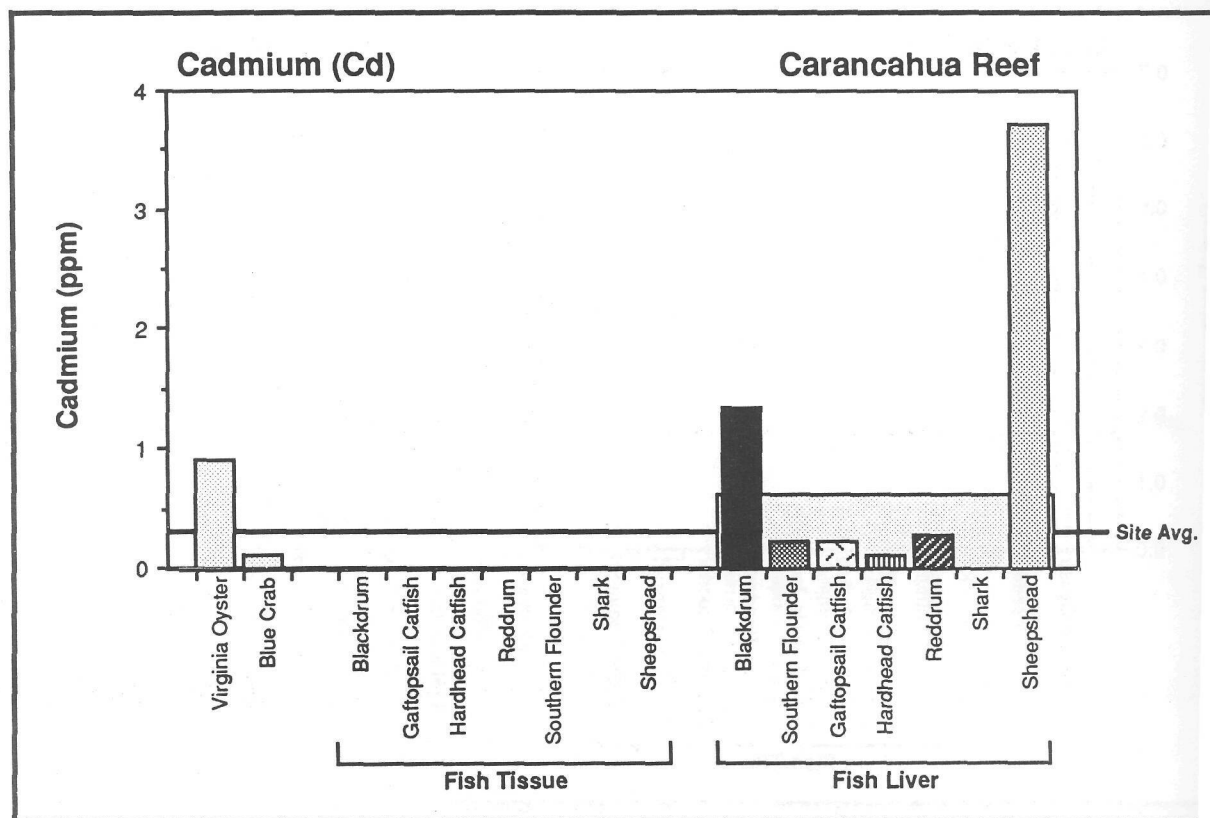
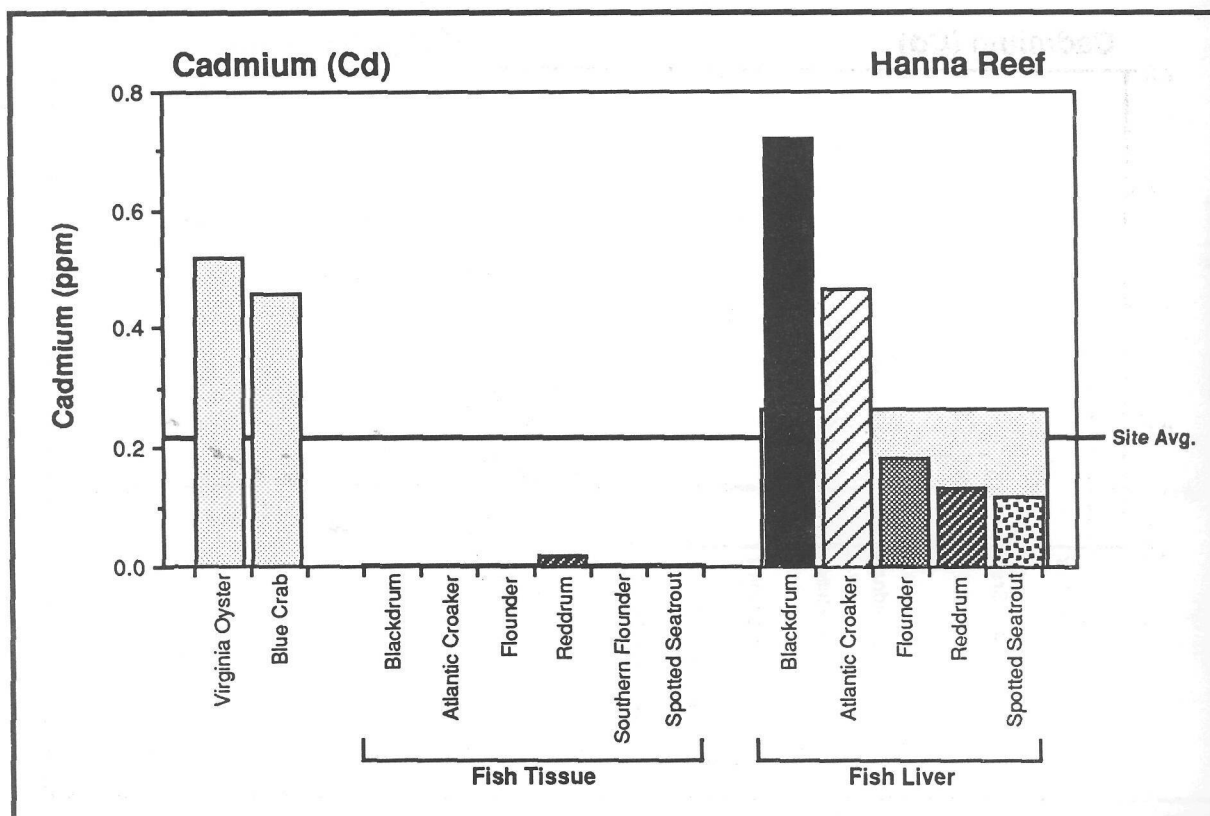


Figure 5.6. Cadmium concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Hanna Reef and Carancahua Reef.

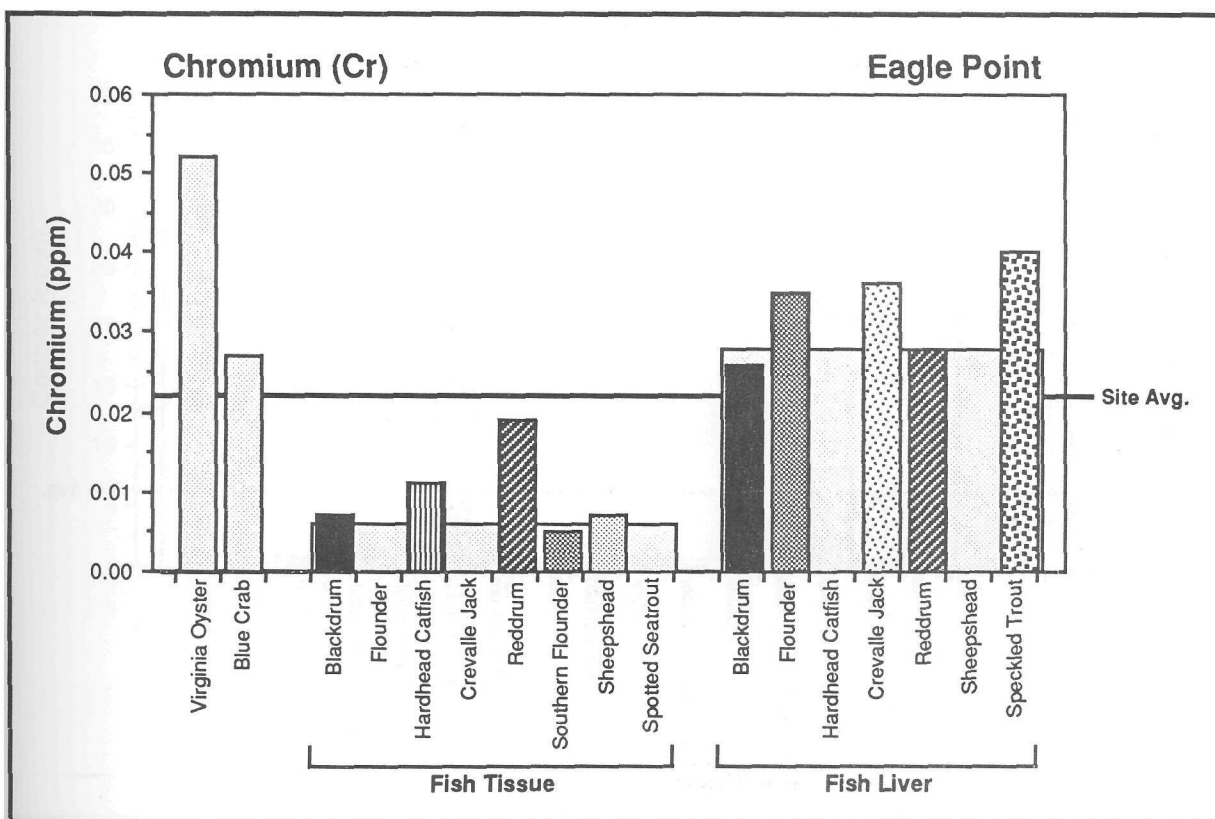
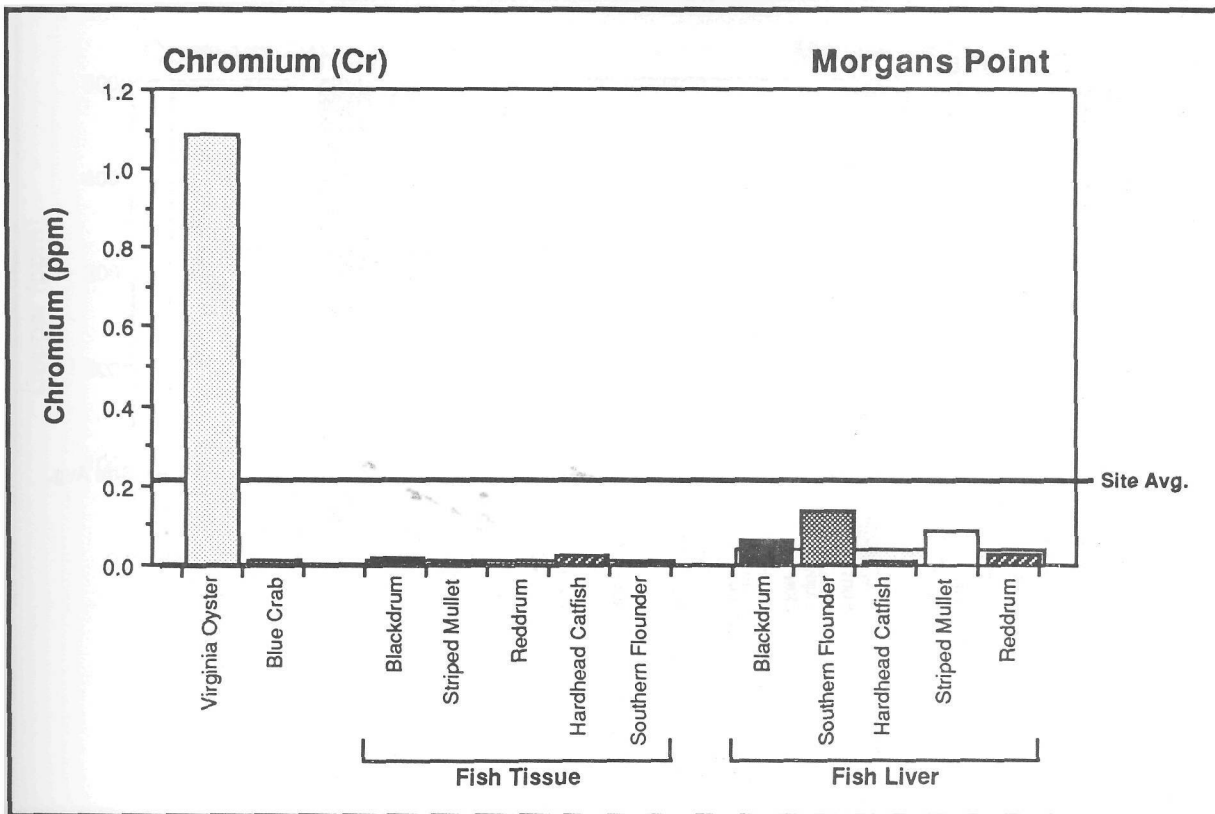


Figure 5.7. Chromium concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Morgans Point and Eagle Point.

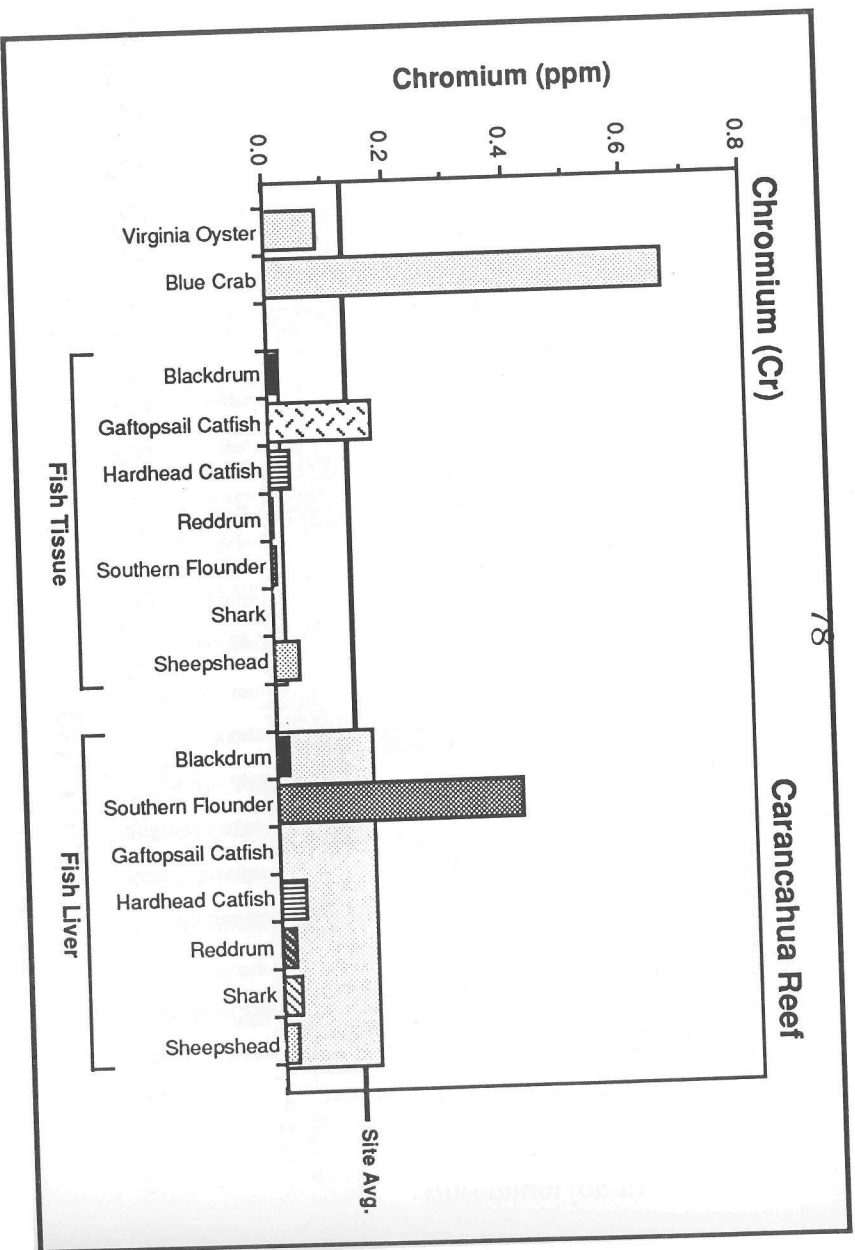
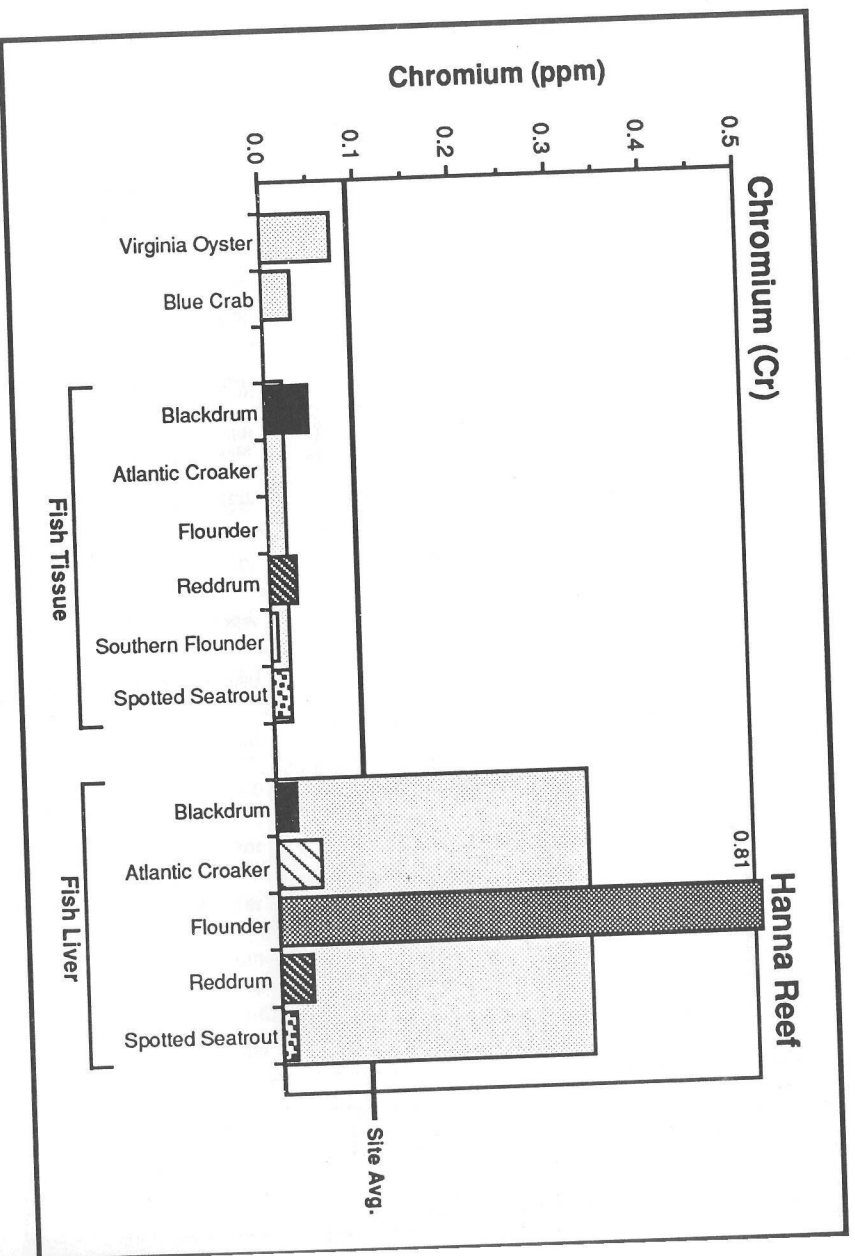


Figure 5.8. Chromium concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Hanna Reef and Carancahua Reef.

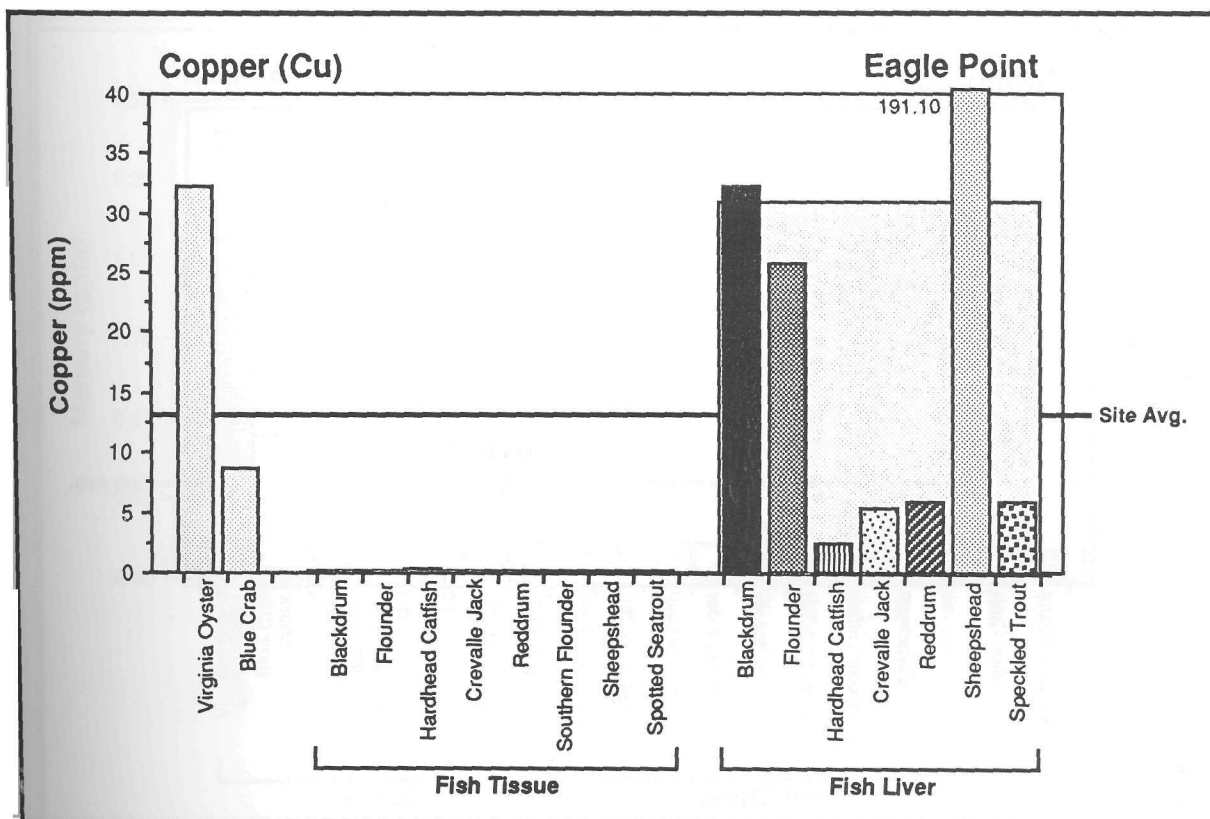
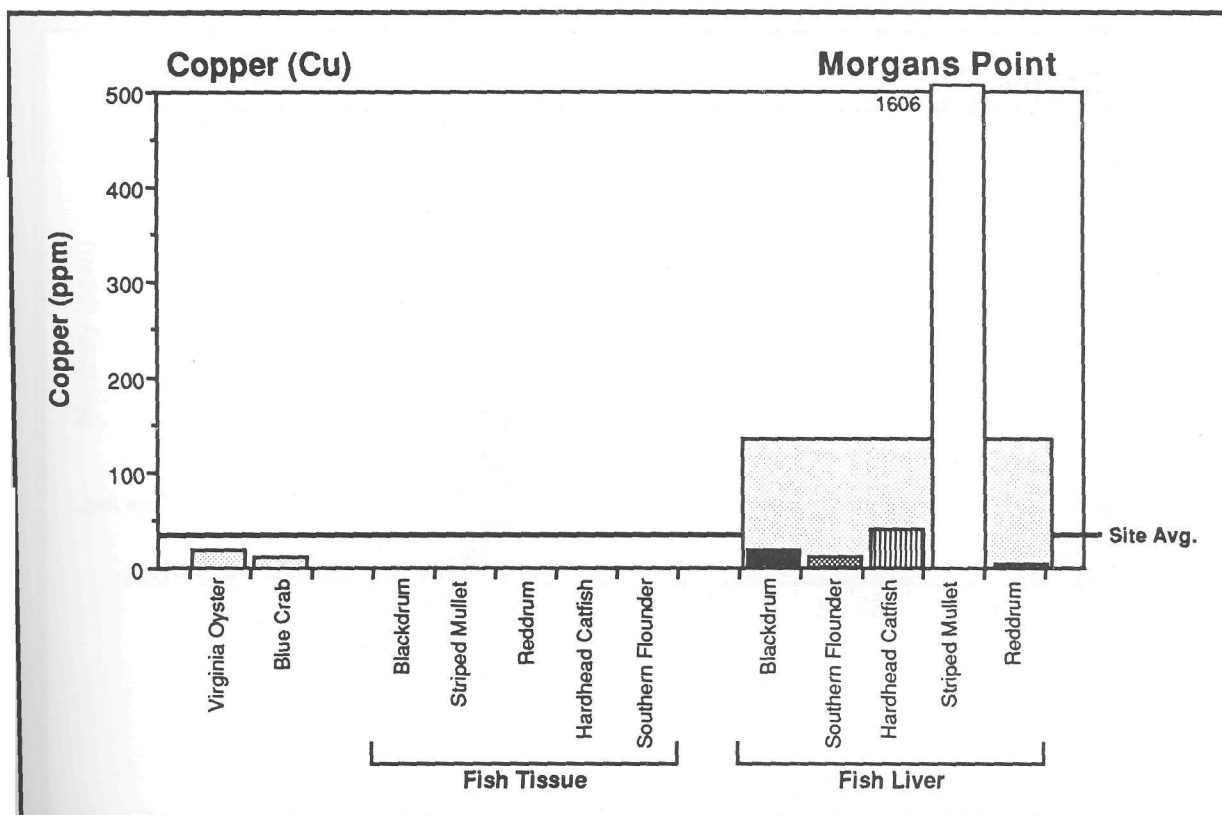


Figure 5.9. Copper concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Morgans Point and Eagle Point.

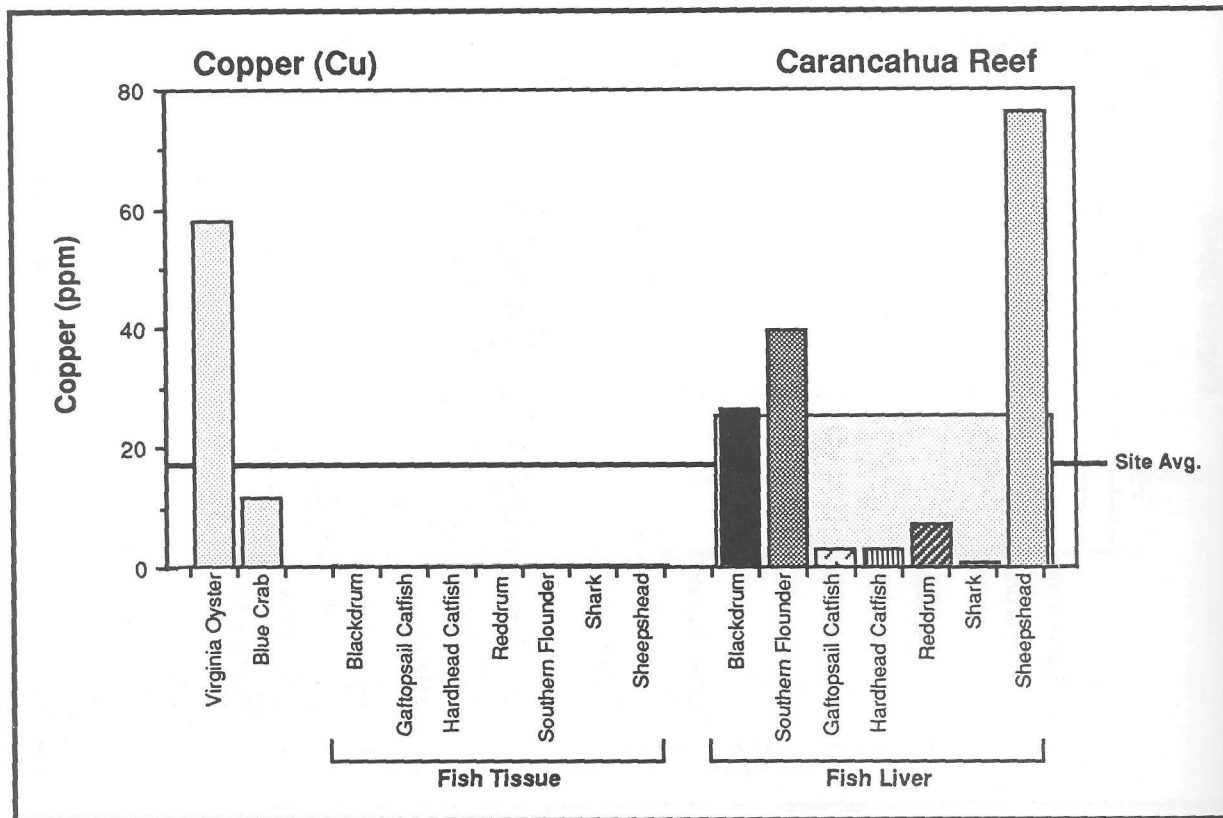
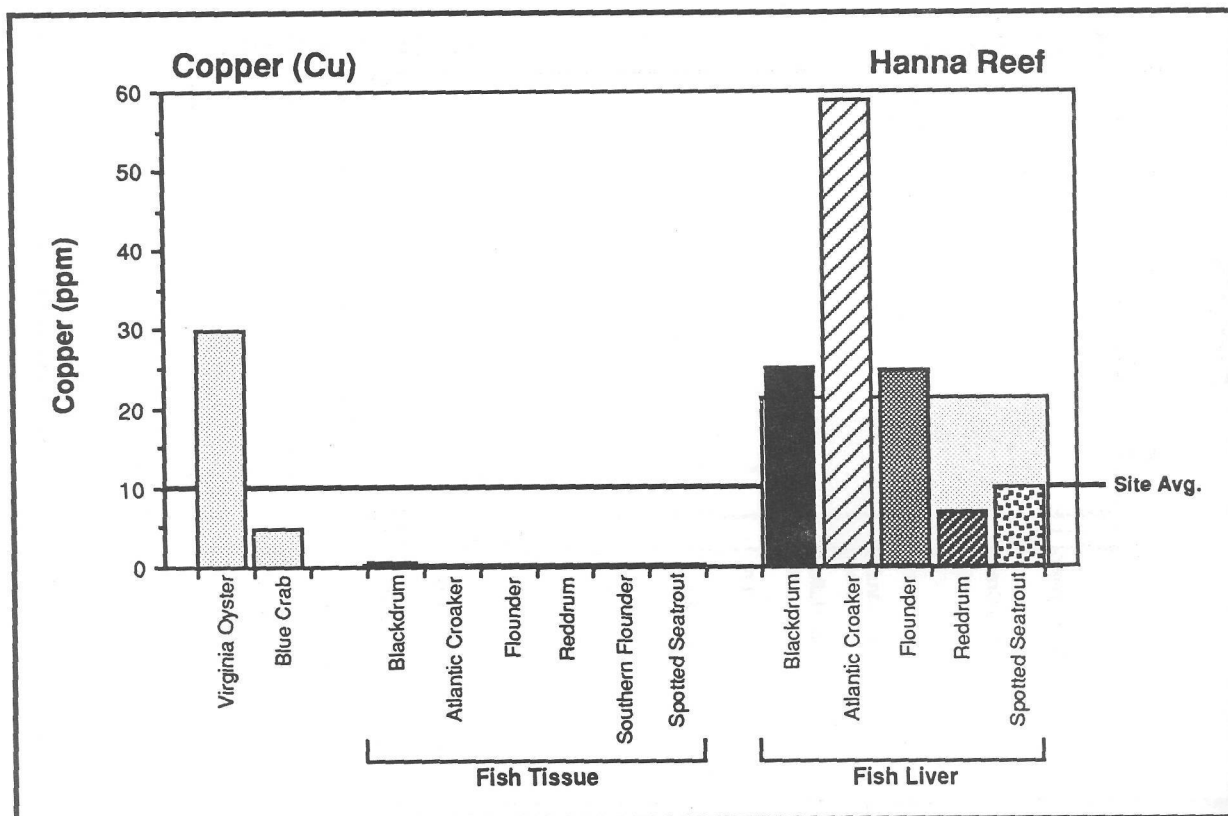


Figure 5.10. Copper concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Hanna Reef and Carancahua Reef.

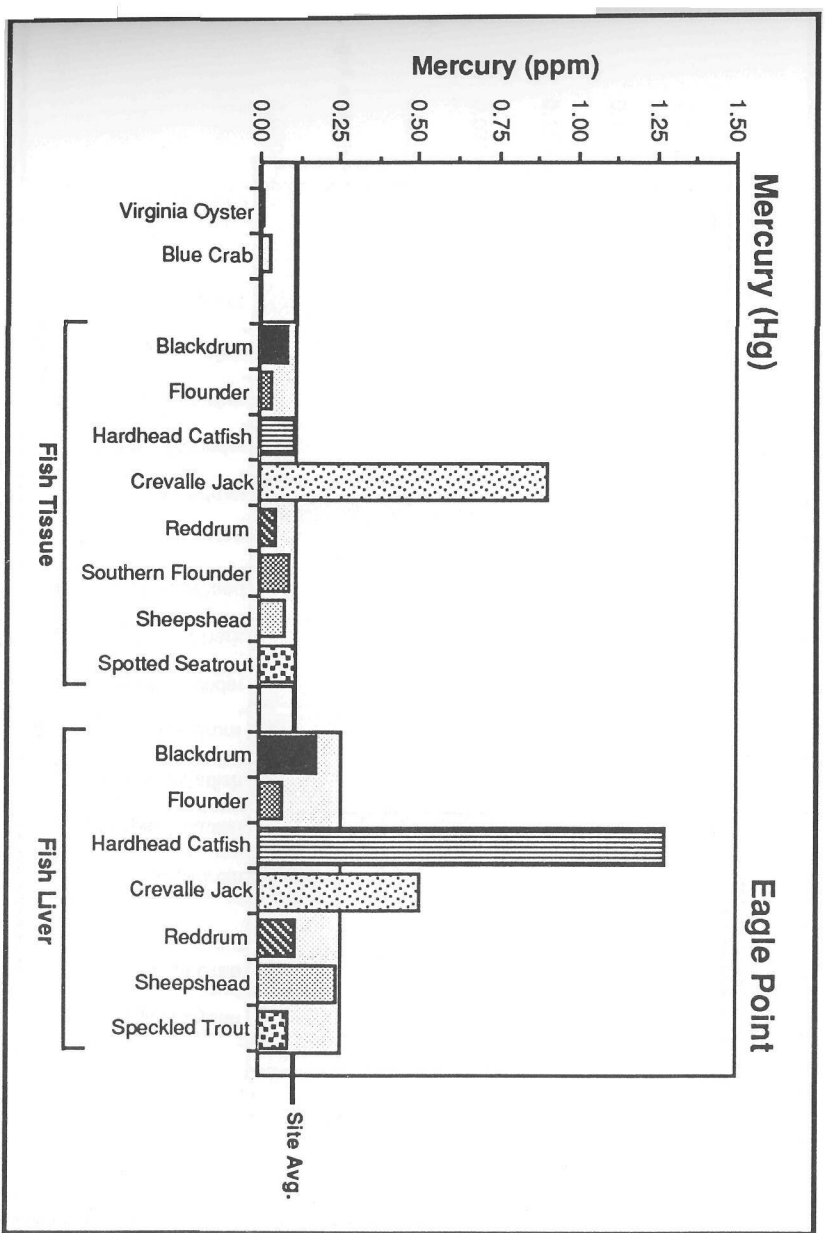
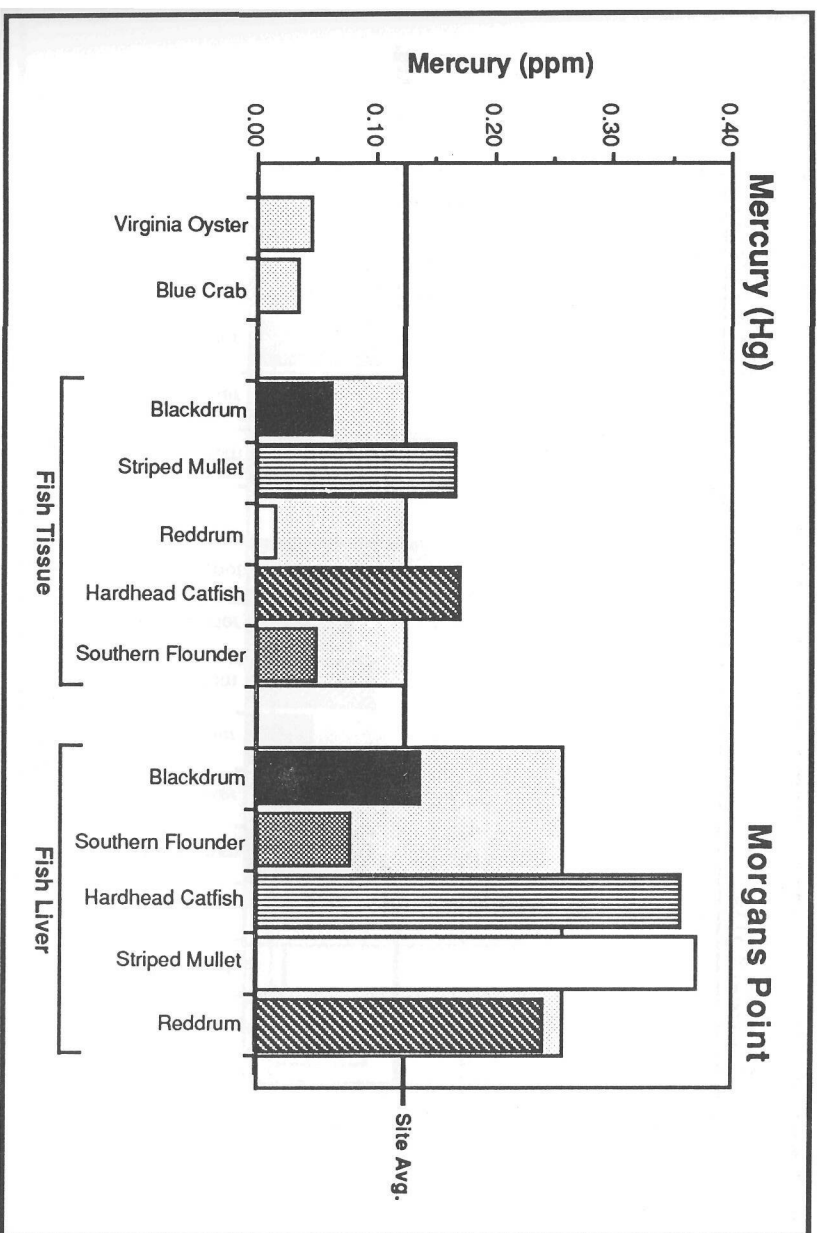


Figure 5.11. Mercury concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Morgans Point and Eagle Point.

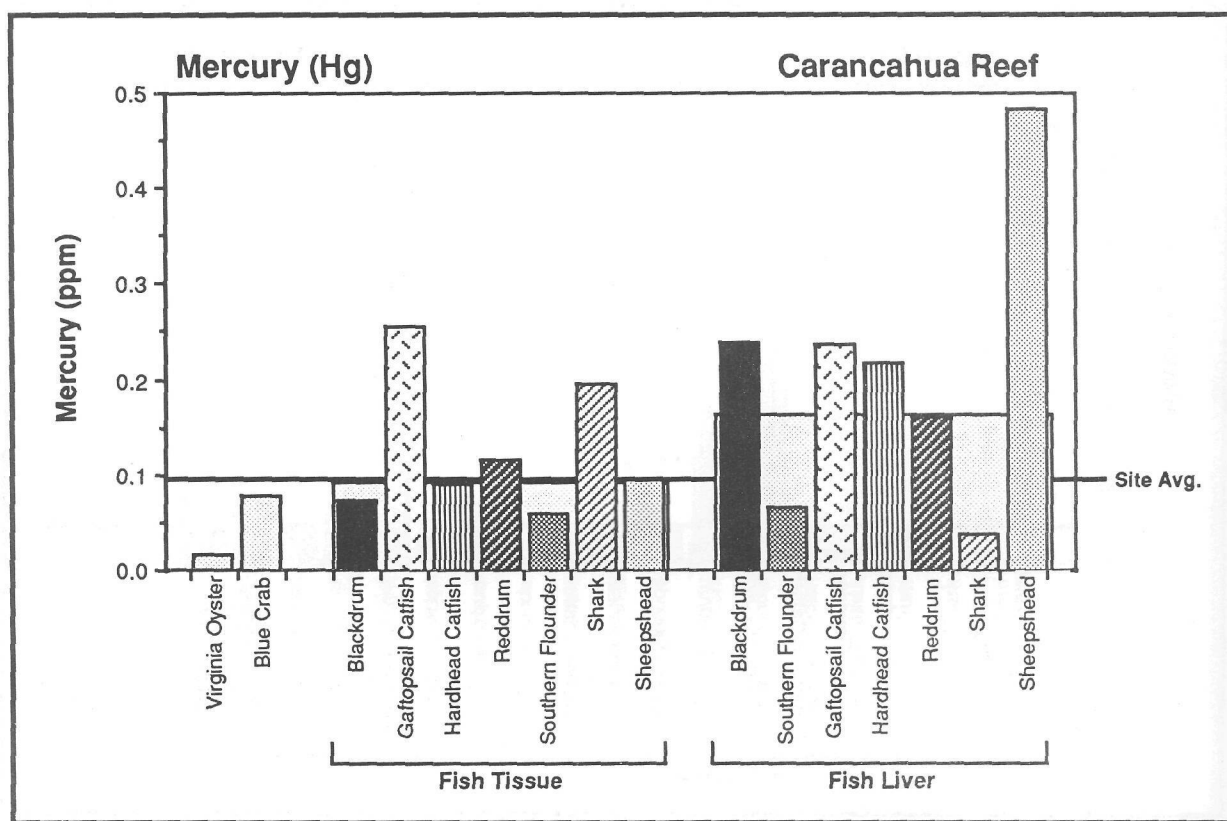
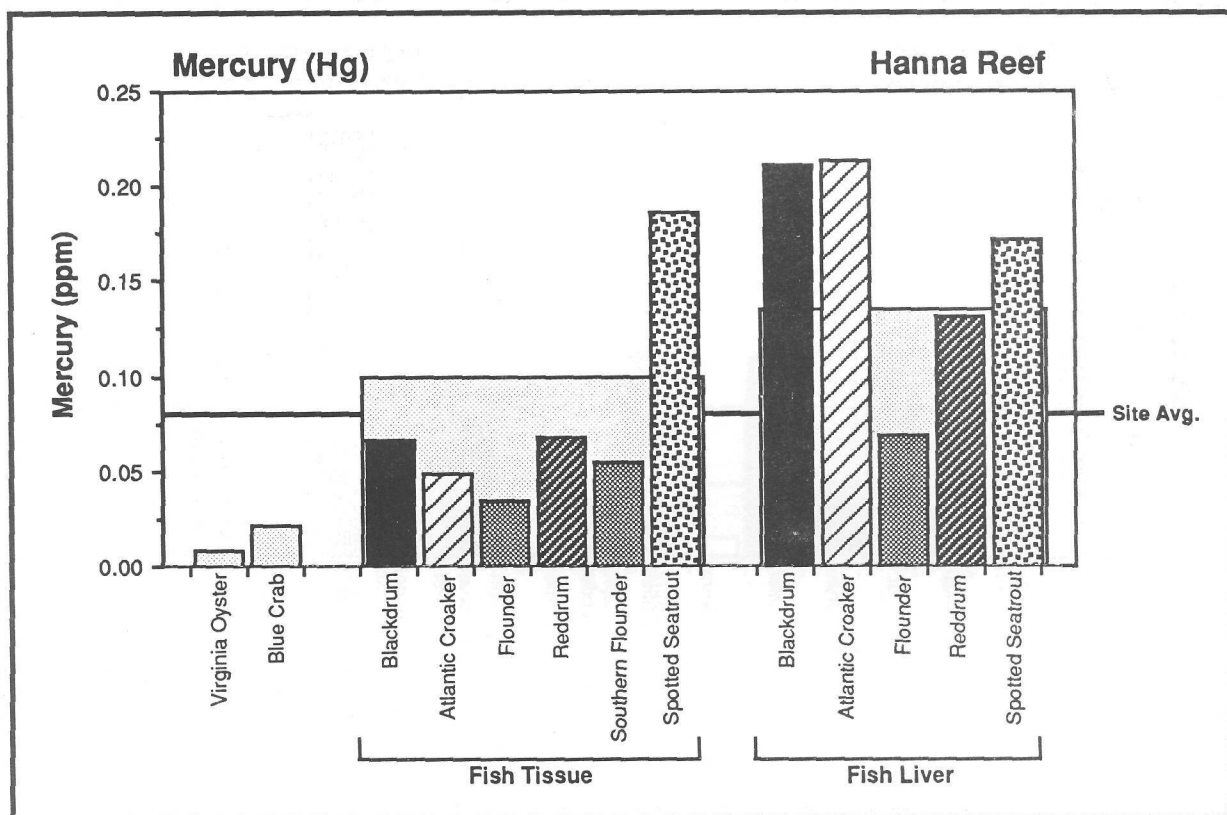


Figure 5.12. Mercury concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Hanna Reef and Carancahua Reef.

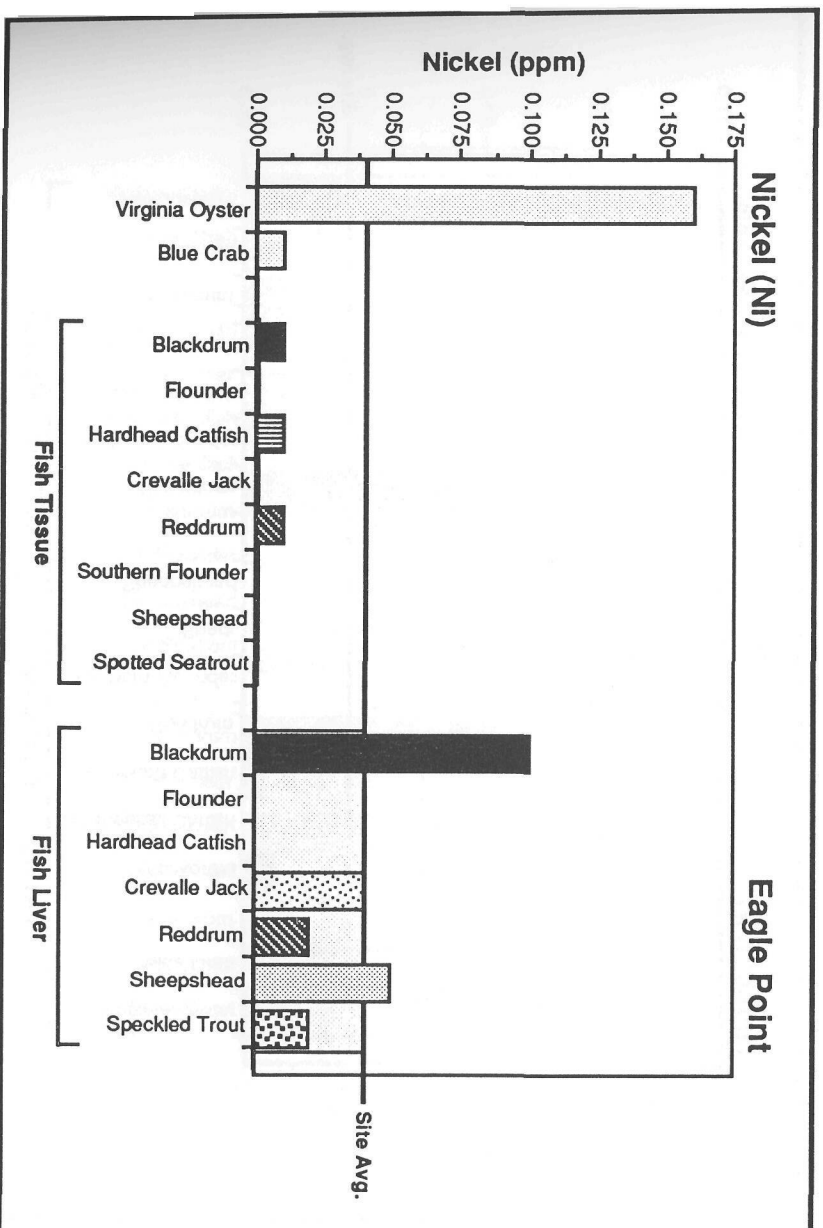
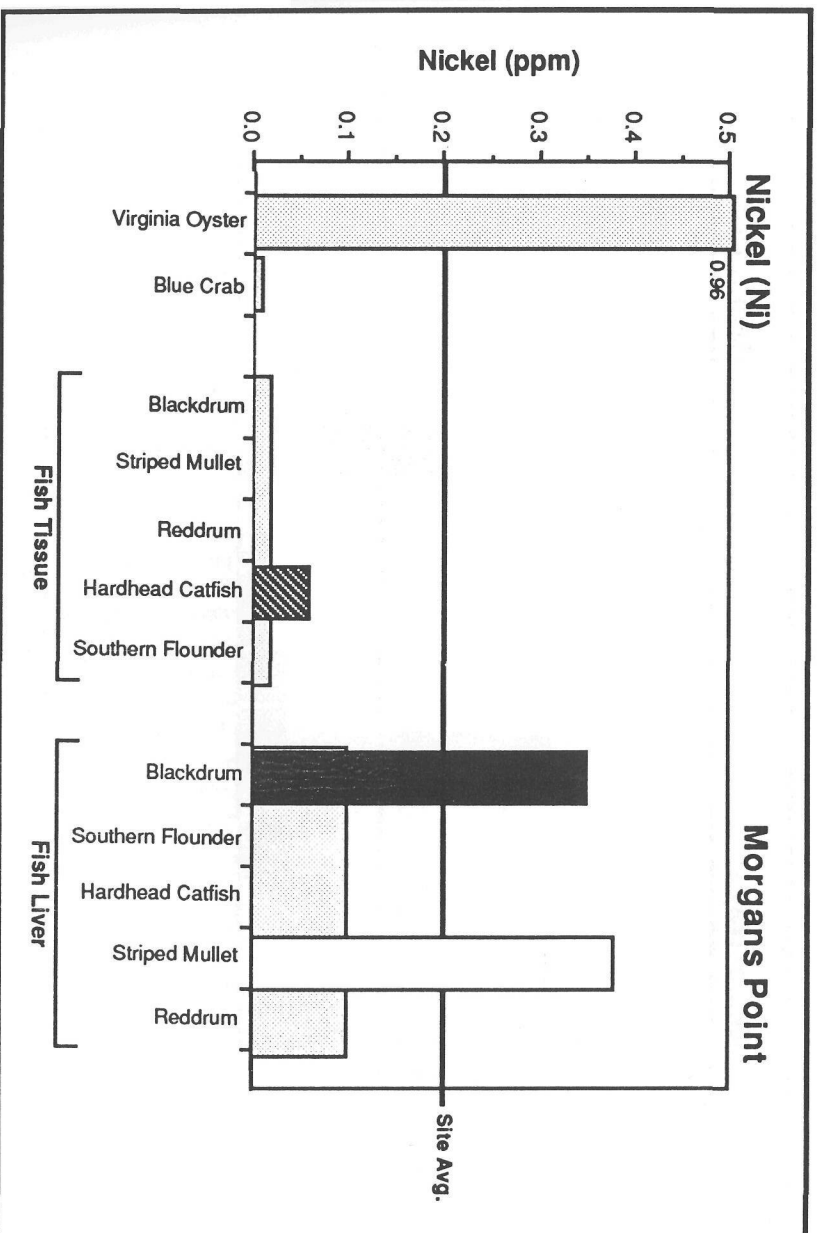


Figure 5.13. Nickel concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Morgans Point and Eagle Point.

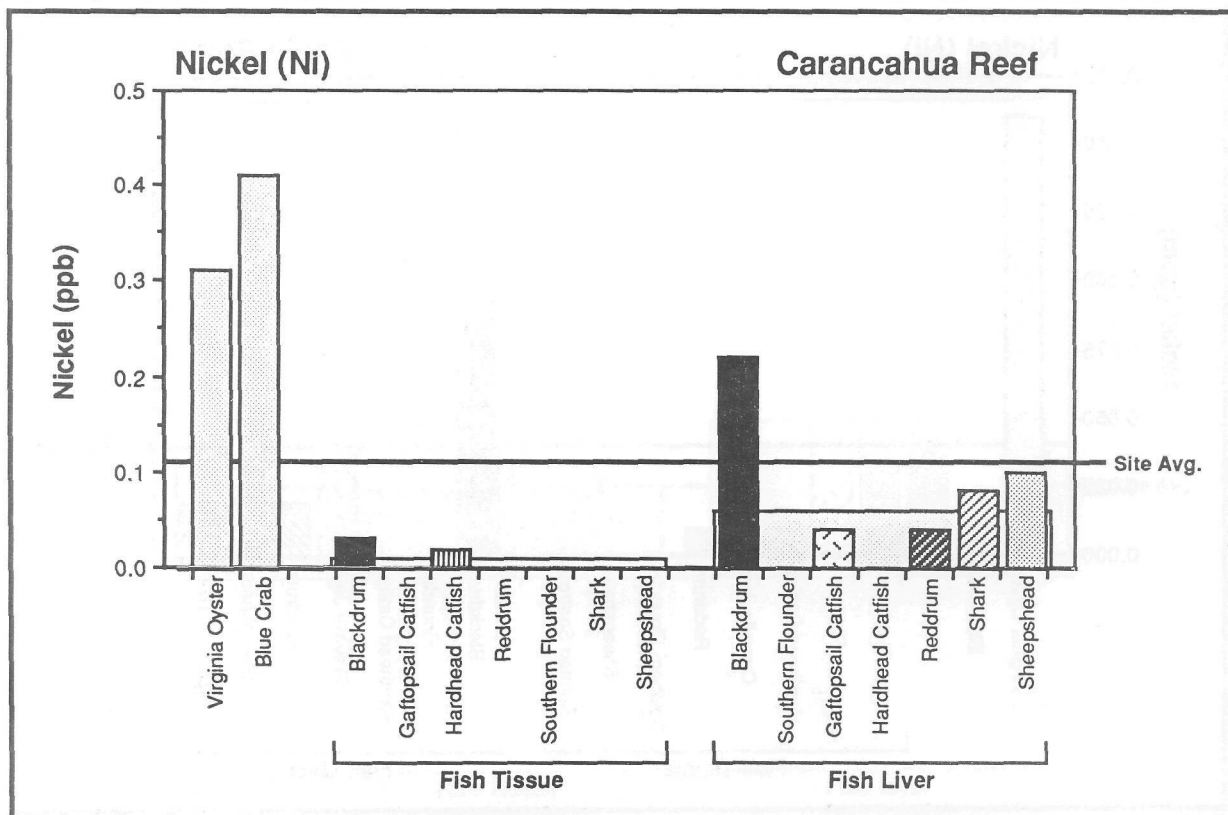
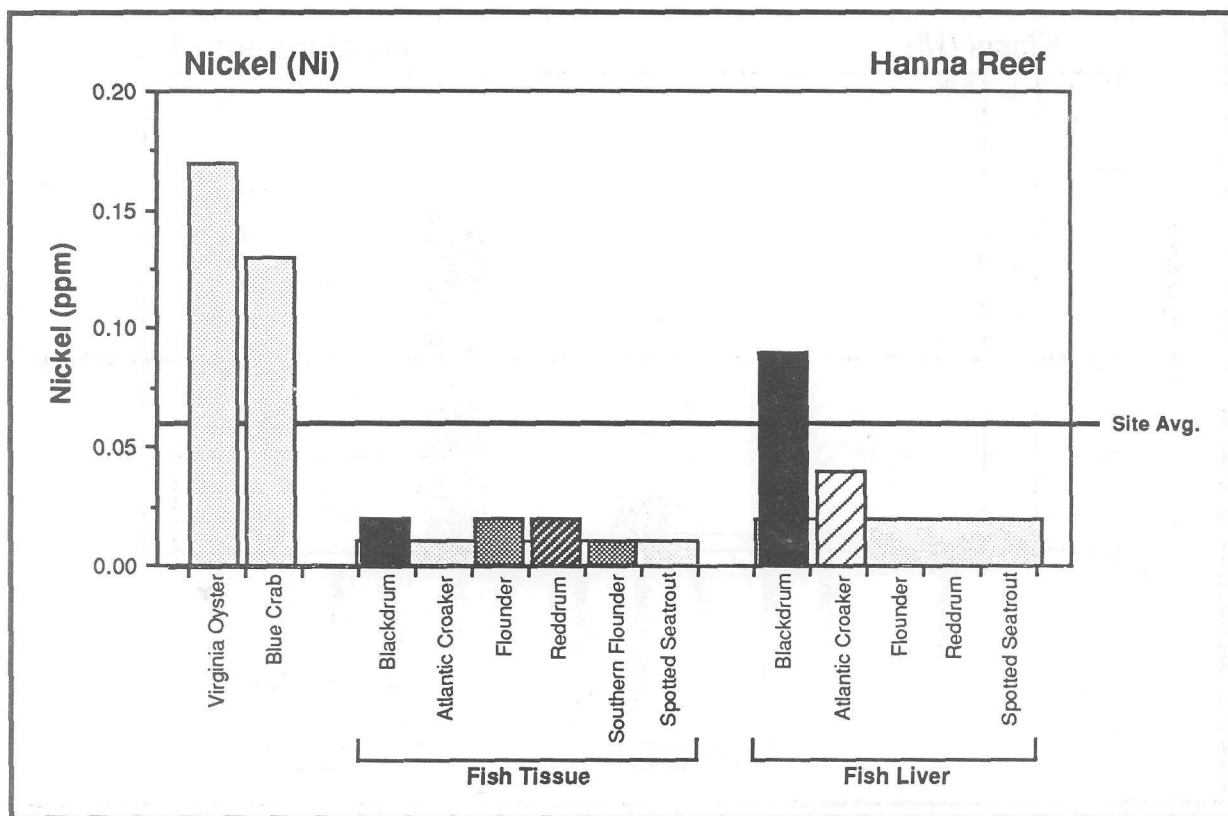


Figure 5.14. Nickel concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Hanna Reef and Carancahua Reef.

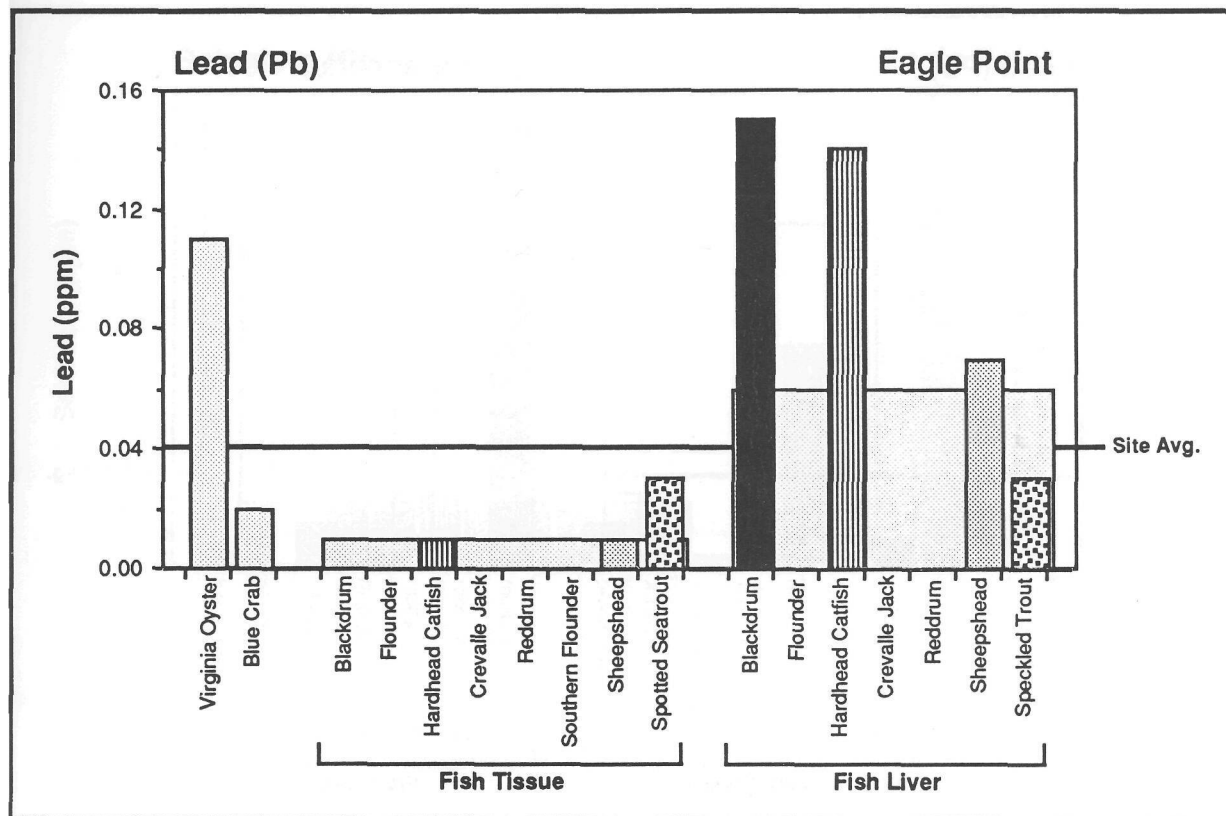
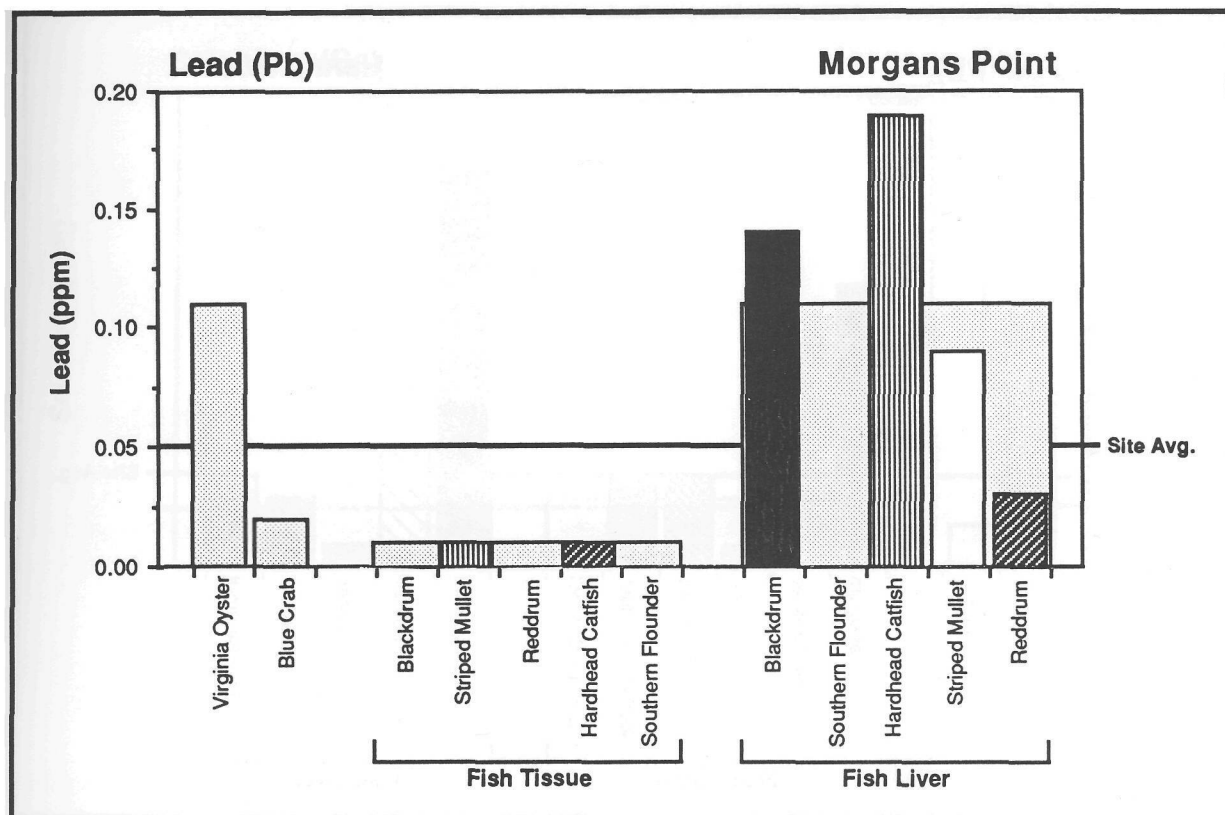


Figure 5.15. Lead concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Morgans Point and Eagle Point.

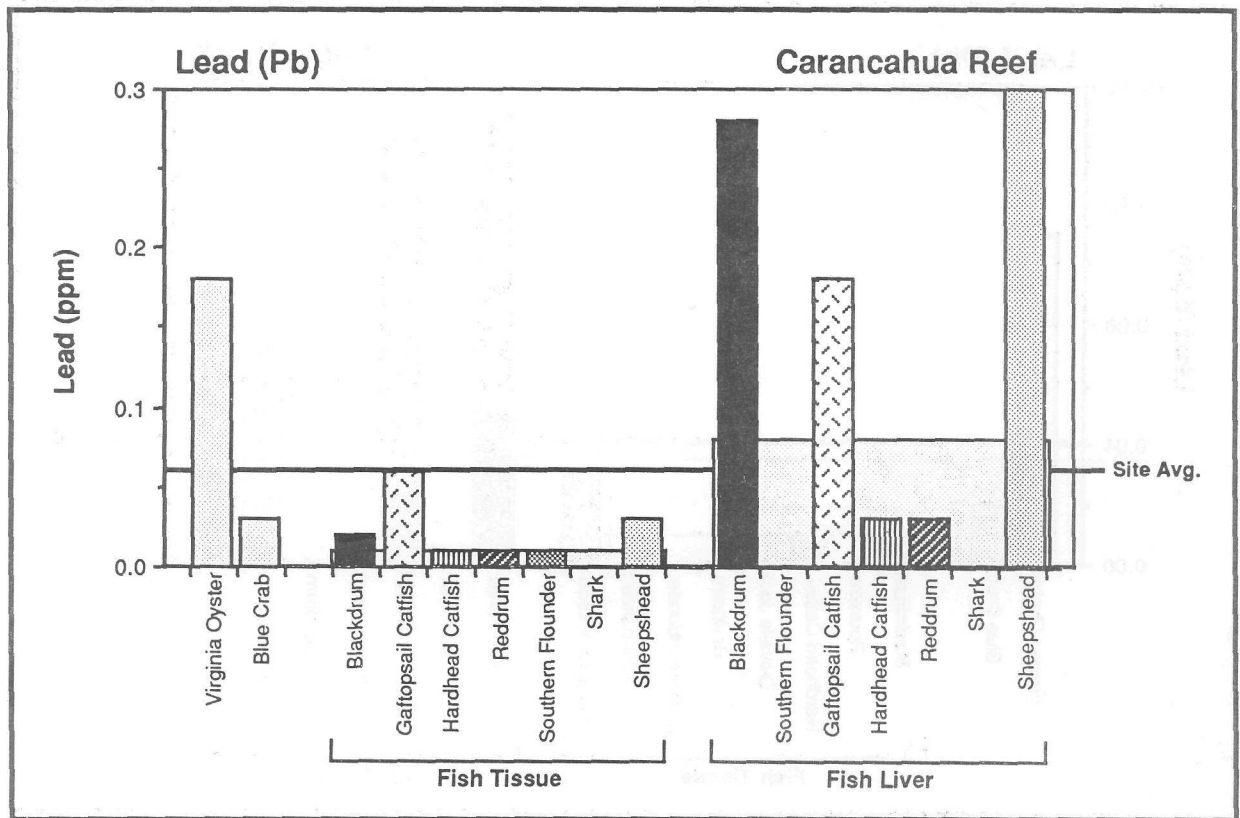
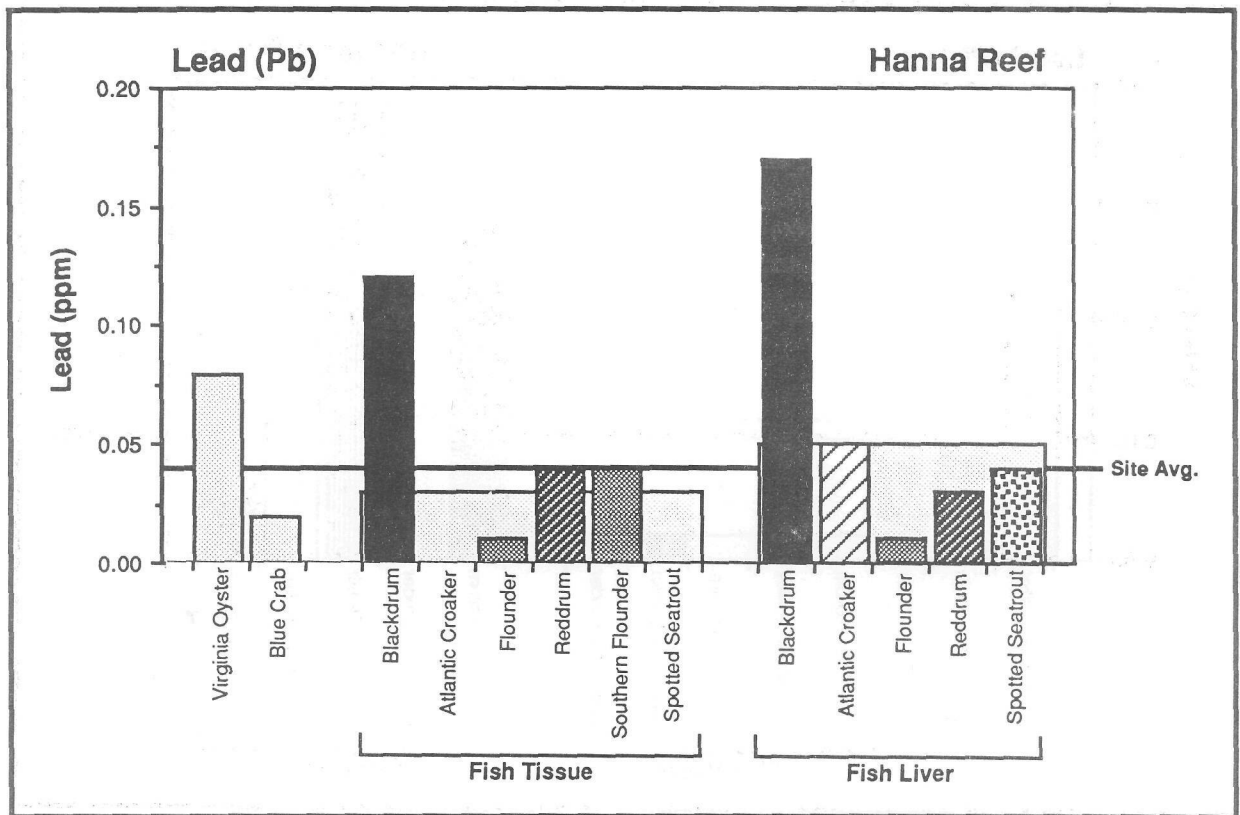


Figure 5.16. Lead concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Hanna Reef and Carancahua Reef.

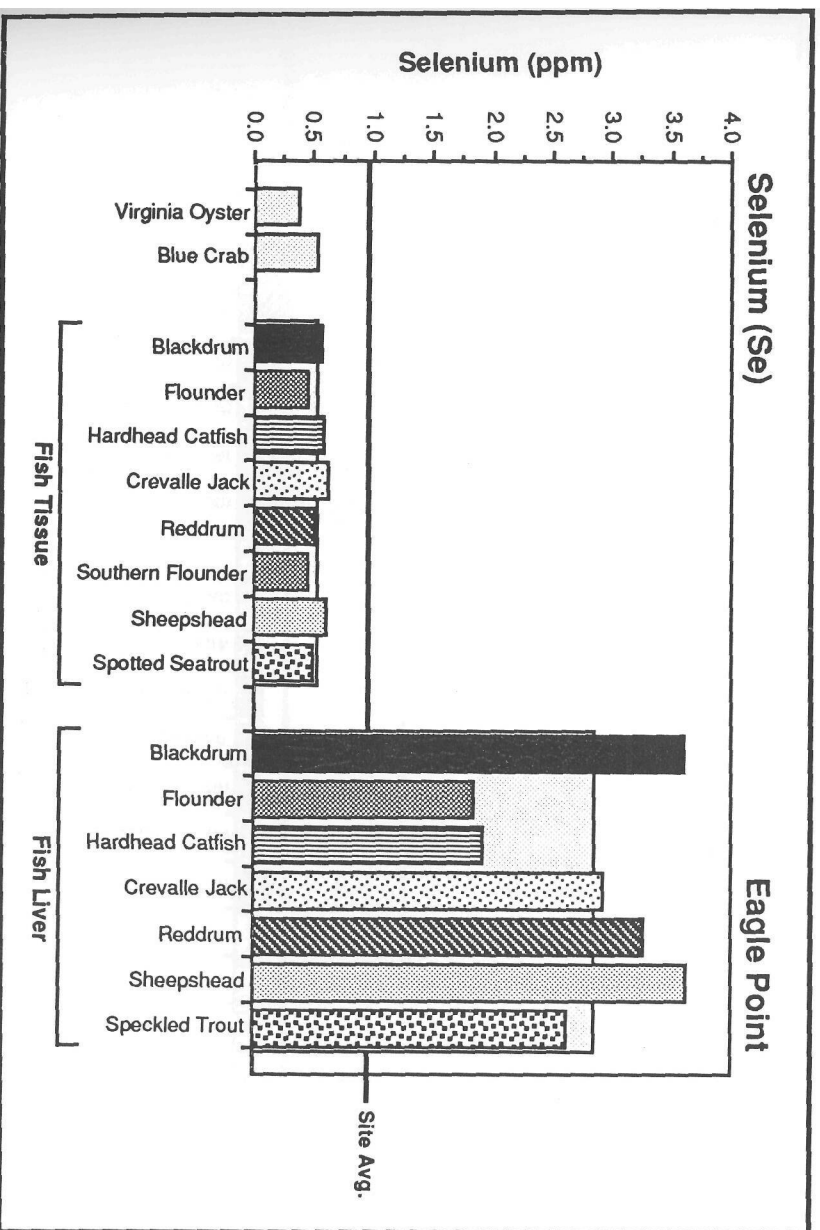
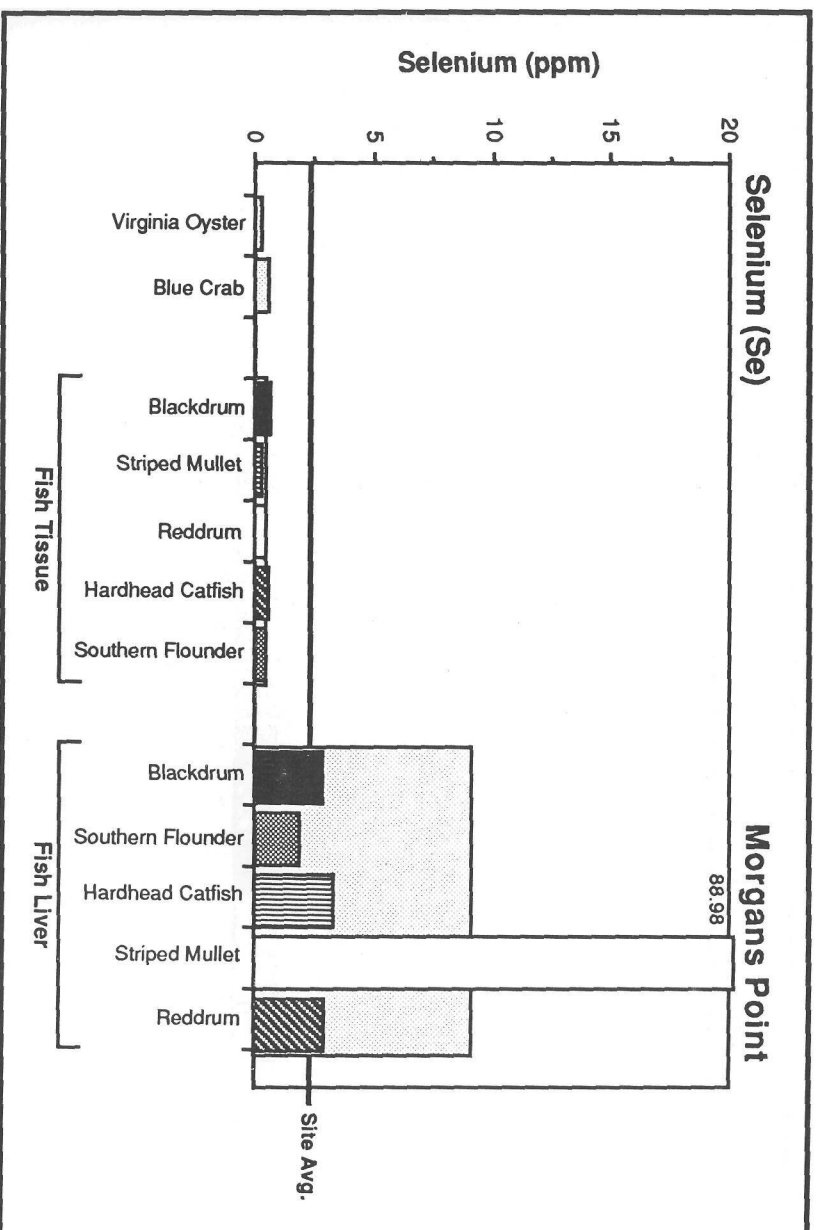


Figure 5.17. Selenium concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Morgans Point and Eagle Point.

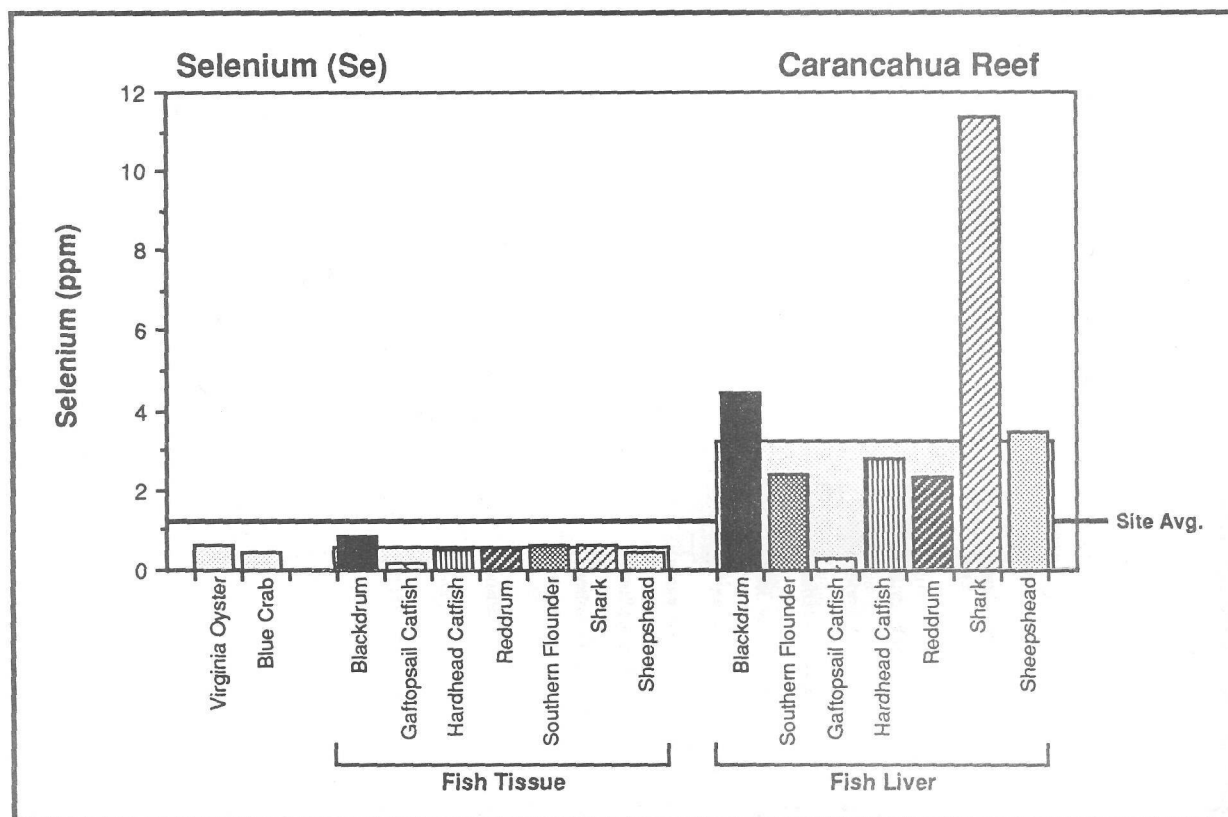
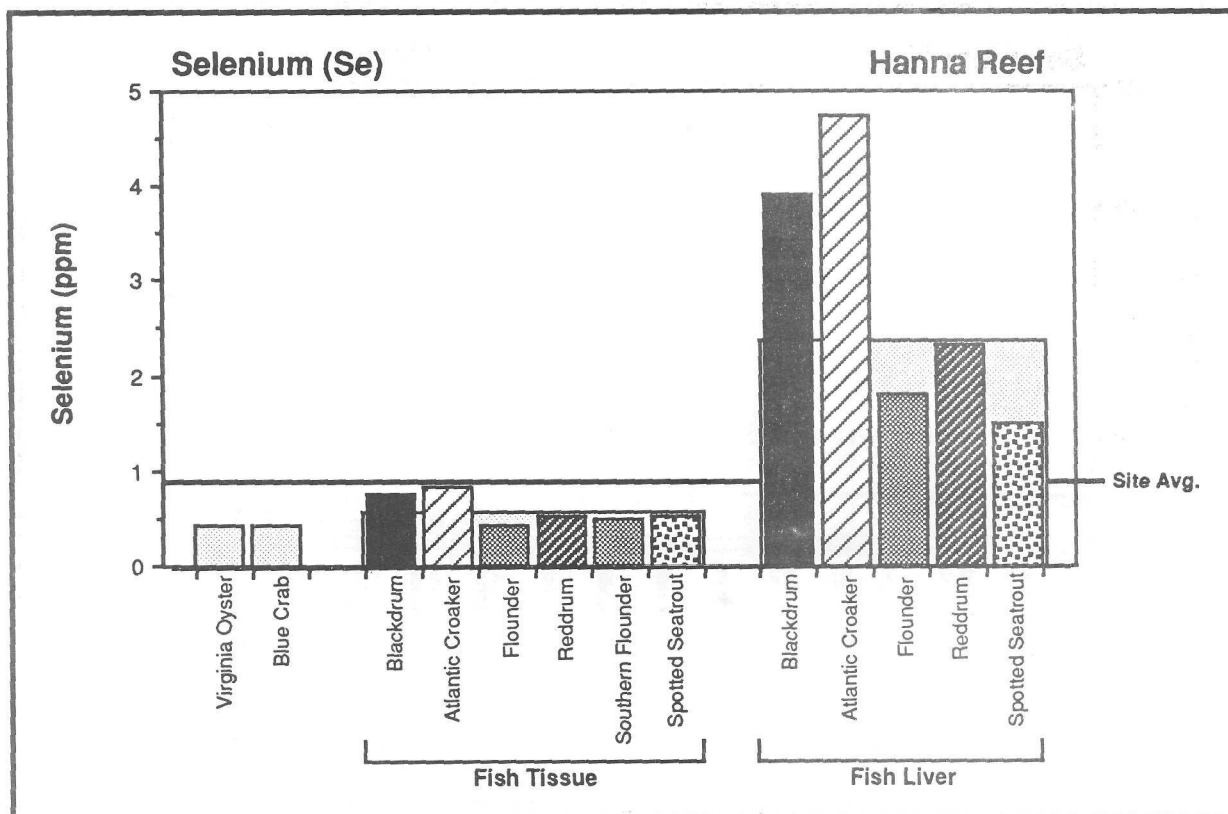


Figure 5.18. Selenium concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Hanna Reef and Carancahua Reef.

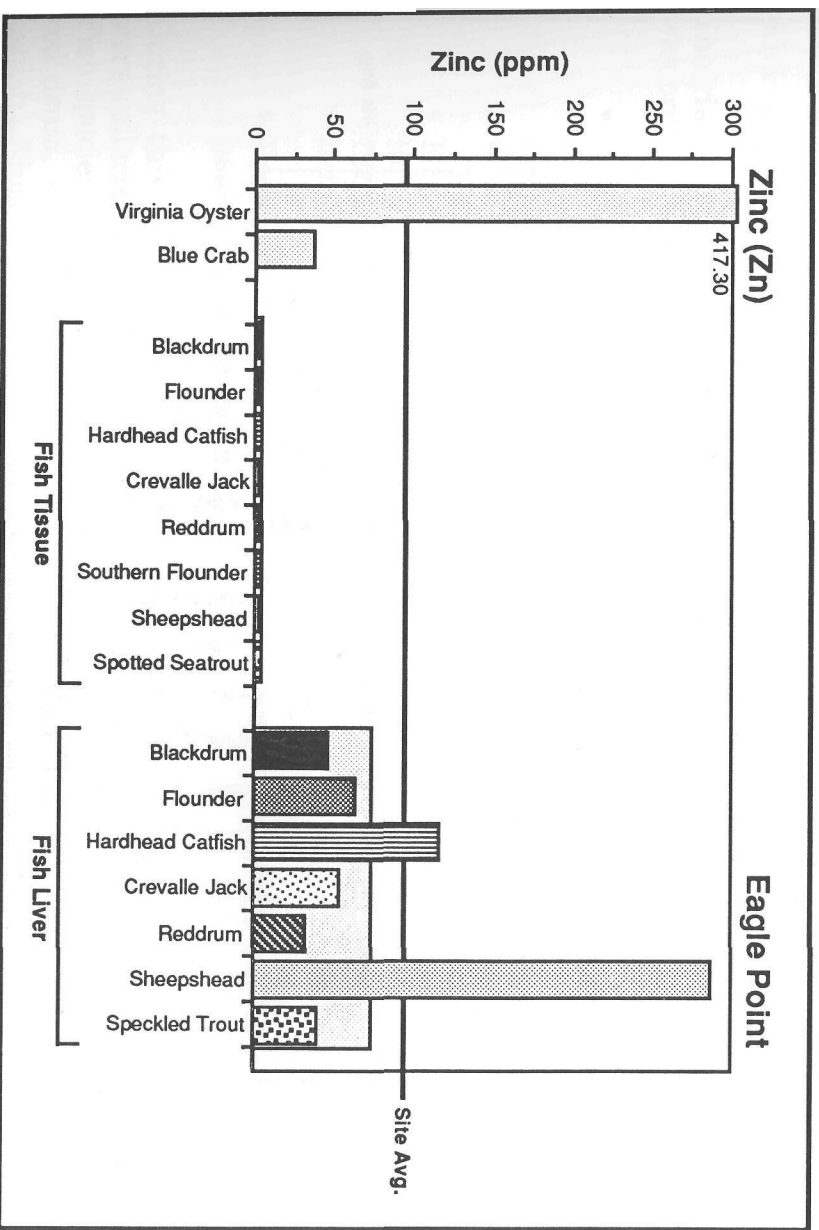
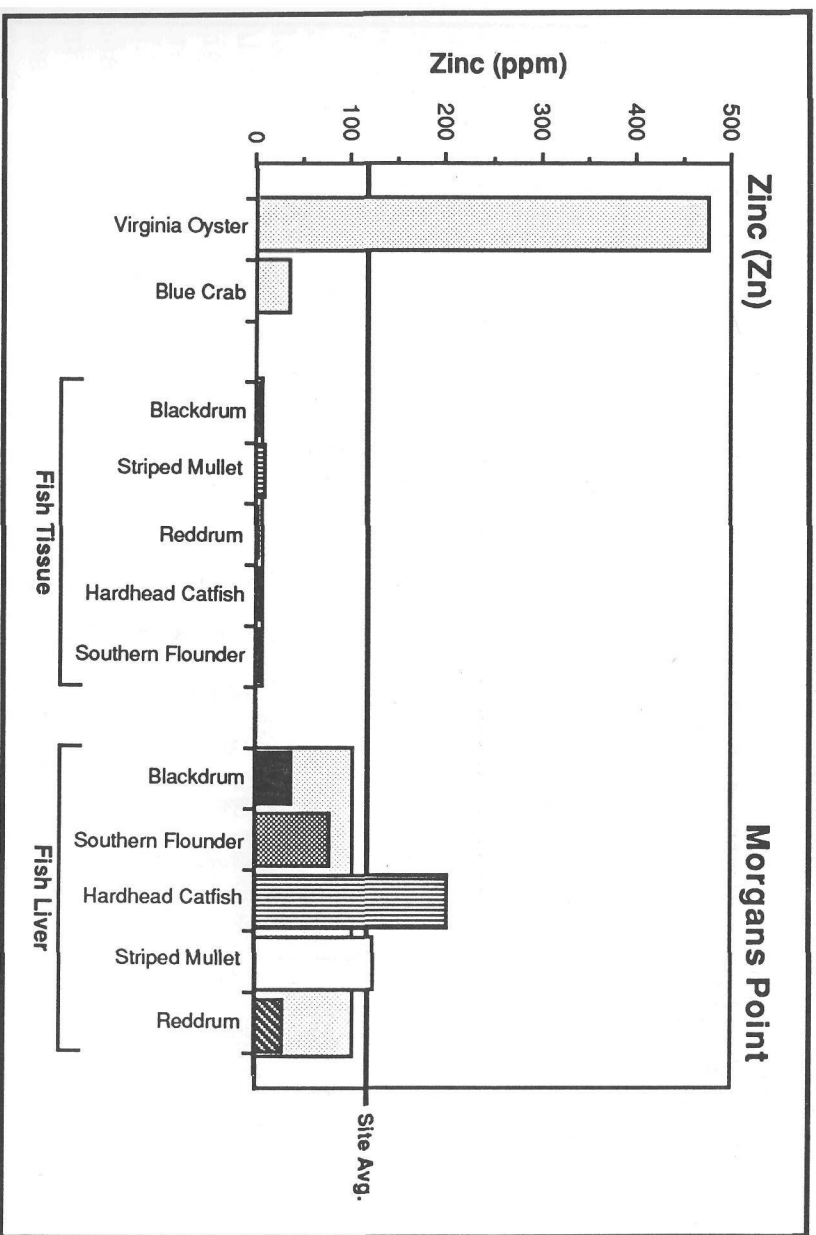


Figure 5.19. Zinc concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Morgans Point and Eagle Point.

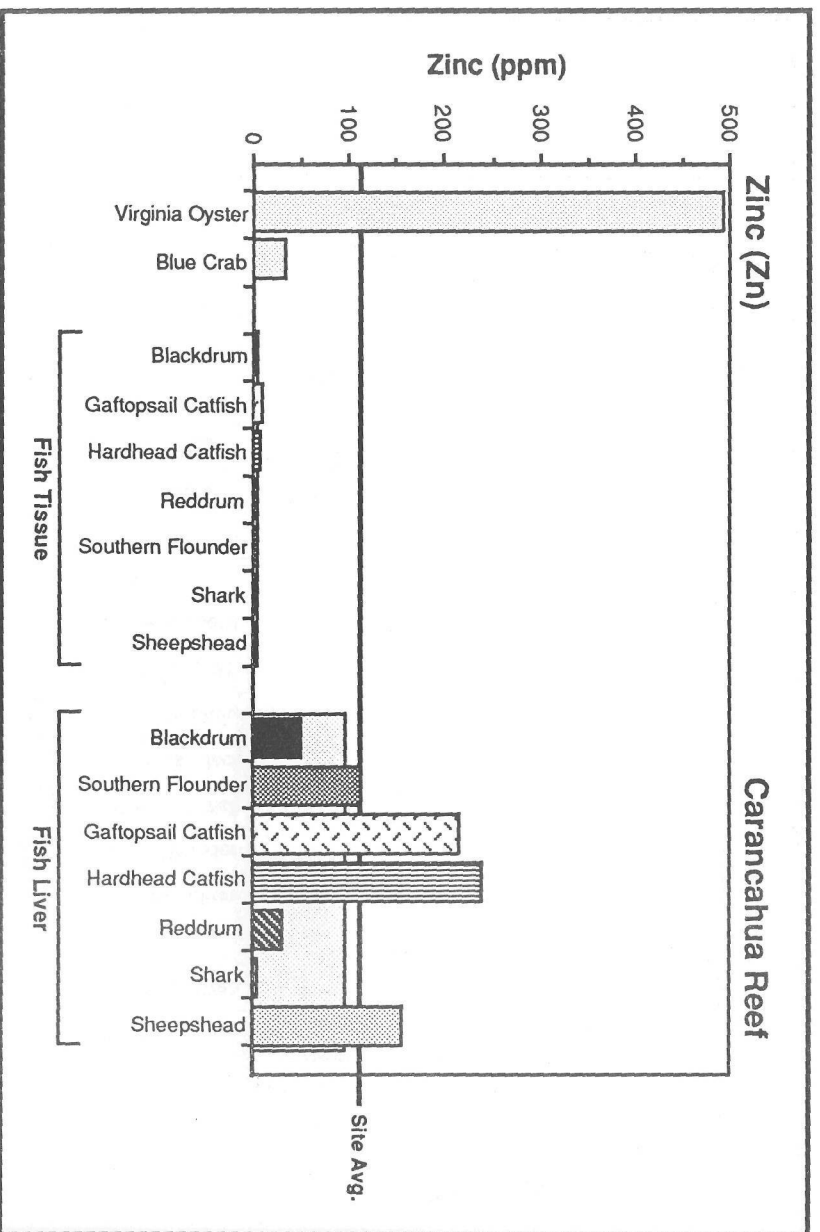
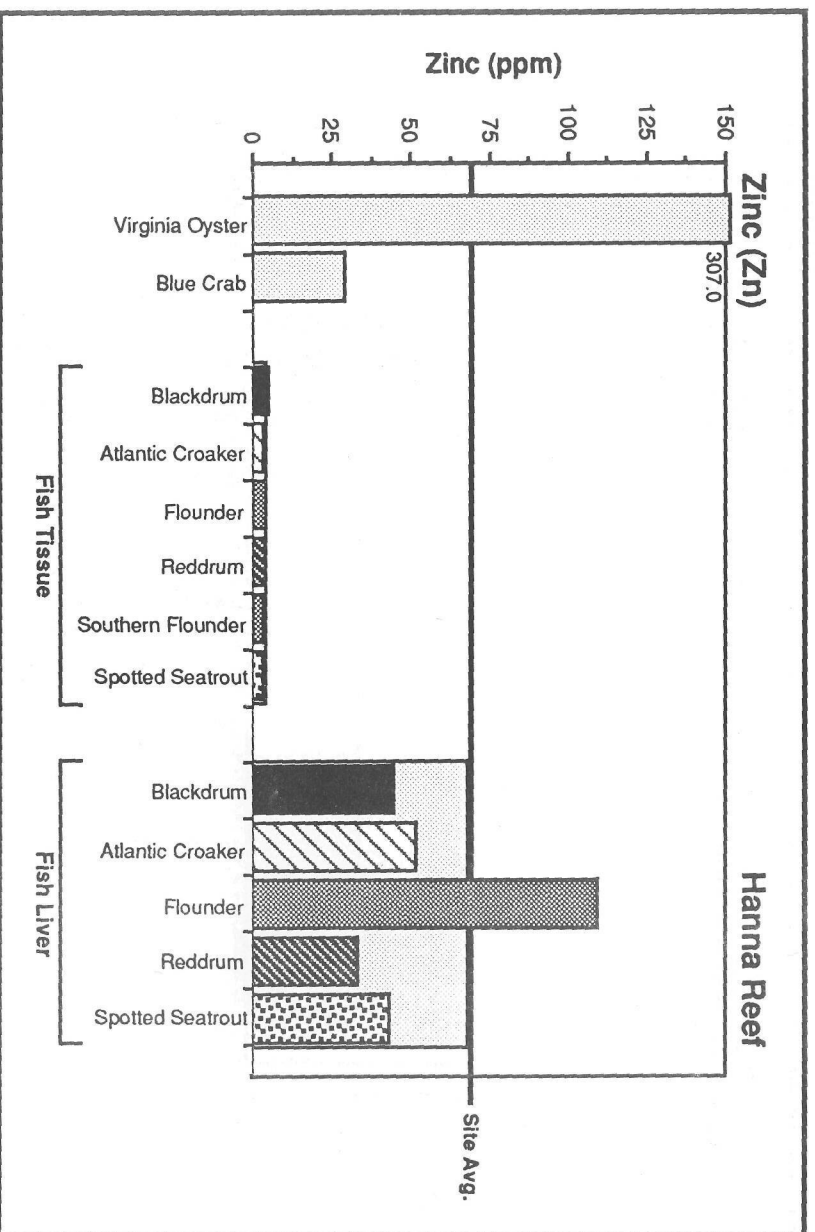


Figure 5.20. Zinc concentrations (ppm) in oysters, crabs, fish tissue, and fish livers from Hanna Reef and Caranahua Reef.